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THE DENTAL COLLEGE SERIES OF TEXT BOOKS.

# THE DENTIST'S MANUAL

OF

## SPECIAL CHEMISTRY

BY

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## PREFACE.

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IN WRITING this book I have tried to give much information in few words, or chemically speaking, "to reduce" Dental Chemistry "to a button." The necessary data have been collected, examined as critically as possible, condensed, and arranged in the order which has seemed proper. I have introduced, wherever possible in the book, such methods of presentation of the various subjects as are particularly my own, suggested by ten years, nearly, of experience in teaching chemistry to medical students. As I intend the book chiefly for students of dental colleges, the reader will excuse attention to detail and careful explanation, of what would often appear simple to the skilled chemist. The first chapter—on Physics and Chemical Physics—is intended chiefly for reference, and will serve to explain many terms used in the body of the work. The second chapter—on reading and writing formulæ—describes the method I use with my own pupils, year after year, to enable them to become familiar with the ordinary formulæ in the shortest possible time; it is by no means intended to be an elaborate essay on Chemical Theory in general, but to serve merely as an explicit guide to the formulæ used throughout this book. I am greatly in hopes that I have made the task of reading and writing ordinary formulæ much easier to the dental student. General chemistry, inorganic or organic, has been studied only so far as relating to dentistry; but I have included in this first edition many compounds which are *indirectly* of interest, so that the student will find a tolerably fair description of almost all the really important chemical compounds. In

the chapter on Metallurgy I have given much that is not found in works on general chemistry, consulting technical works as well as chemical, and I hope that the dental student will find information in this chapter, which will be especially valuable to him. Alloys, Amalgams, and Cements have been studied carefully, and the chapters on these substances mark the special character of the book more, possibly, than any others. I have given a special chapter to Ferments and the relation of the germ theory to dentistry, endeavoring, however, as far as possible to adhere to matters strictly chemical; in this chapter, germicides, antiseptics, etc., have been discussed, and the individual preferences of many authorities in dentistry described. I have gone into the chemistry of tooth structure, with the view to see the dental student able to make an analysis, qualitative and quantitative of the teeth, saliva, tartar, and calculi. I have tried to map out methods by which this may be done, under the hands, of course, of a competent instructor. Laboratory work with the blowpipe, and tests for the alloys and cements are not of great difficulty, and the student may find such work simplified in chapters XVIII and XIX.

It is, however, more than I could expect that the first edition should be satisfactory in all respects. All that I hope is that it may serve as a foundation for future work, and that it may stimulate dental students to engage as actively in the study of the special chemistry of dentistry as medical students engage in the study of the special chemistry of medicine. I shall be greatly disappointed not to receive, at once, suggestions and criticisms from the Dental Faculty. Subsequent editions will be brought out, I hope, under the guidance and direction of those in charge of Chemistry in Dental Colleges, this first edition serving as a basis on which to map out a systematic course of instruction for the future.

I have endeavored to give credit as far as possible throughout the work to those whose books I have consulted. Among my authorities on Physics have been Ganot, Deschanelles, Miller, Gage, Avery, Barker, Bartley; on Chemistry, Bloxam, Watts, Wurtz, Gmelin, Roscoe, Schorlemmer, Allen of Sheffield, Bartley, Oldberg and Long, Eliot and Storer, J. P. Cooke, Bloxam and Huntington, Charles, Ralfe,

Gamgee, Frey, Gilbert Wheeler, Fremy and Terreil, Jungfleisch, Kruckenberg, Fresenius, and here and there many others. For the presentation of the subject of organic theory I must again, as in my "Physician's Chemistry," acknowledge my indebtedness to Professor W. Simon whose work on Chemistry should be read by every medical and dental student. In pharmaceutical chemistry I have been greatly helped by the masterly treatise of Oldberg and Long. The short sketch of urinary analysis is largely the result of my own experience, but I must acknowledge help from Dr. F. R. Cruise, of Dublin, for his paper on "Quantitative Examination of Albumin, Sugar," etc. I am indebted to T. Storer How for his plan of litmus tests of the saliva. The journals which I have consulted have been necessarily numerous, and a list of them would occupy too much space in this preface. I have quoted very often from the *Medical Record*, the *Therapeutic Gazette*, the *American Druggist*, the *Popular Science News*, and the *Dental Cosmos*, and must not omit to acknowledge my indebtedness to these journals, if to no others.

In regard to matters chiefly dental, my authorities have been Flagg, Essig, Gorgas, Richardson, Black, Wildman, Miller, Allport, Morsman, Harlan, Talbot, Hunt, Hunter, Gilbert, Black, Abbott, Vergne, Palmer, Brackett, and others, whose names will be quoted throughout the work in connection with the subjects concerning which they have furnished me with information. My authority for the uses of chemical substances in dental medicine has been the work of Professor Gorgas, and I am greatly indebted to this book moreover for my choice of matter, the chemistry of which I should bring before the dental student. I have been encouraged in the arduous labors attendant on the bringing out of my book by many expressions of good will and interest on part of members of the dental profession. My thanks are due in the first place to Professor A. O. Hunt for his kindly interest, invaluable suggestions, and untiring efforts in behalf of the cause of Dental Chemistry. It is perhaps needless to say that the book would scarcely have appeared now as it does, in 1887, had it not been for the encouragement and approval of Dr. Hunt. I must render thanks to Dr. Frank H. Gardiner for his hearty co operation



in all matters pertaining to the book; to Professor Harlan for valuable suggestions relating to dental text-books and authorities; to Profs. Abbott, Cassidy, Guilford, and Truman for letters expressing kindly interest. So much help has been given me and from so many quarters that it is barely possible that I have forgotten to thank all in this already too long preface. It is sufficient to say that I feel amply repaid already for the work I have done.

CLIFFORD MITCHELL.

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# Dentist's Manual of Special Chemistry.

## CHAPTER I.

### PHYSICS AND CHEMICAL PHYSICS.

1. **Matter.**—Anything which possesses weight or occupies space.
2. **Divisions of Matter.**—Mass, molecule, atom. (See also page 17.)
3. **Mass.**—Quantity of matter made up of molecules.
4. **Molecule.**—Smallest subdivision of matter which can exist by itself.
5. **Atom.**—Smallest quantity of matter that can by combining form the molecule.
6. **Attraction of Mass,** or molar attraction: same as attraction of gravitation.
7. **Molecular Attraction.**—Cohesion or adhesion.
8. **Atomic Attraction.**—Chemism or chemical affinity.
9. **Molar Motion.**—The ordinary visible mechanical motion, as that of a machine or its parts.
10. **Molecular Motion.**—Heat, light, magnetism, electricity.
11. **Atomic Motion.**—Hypothetical.
12. **Properties of Matter.**—Qualities characteristic of matter. Two kinds, physical and chemical.
13. **Physical properties of matter.**—The different ways in which matter presents itself to our senses. Two kinds, general and specific, or universal and characteristic. *General* properties are those common to all matter, as impenetrability, extension, porosity, etc. *Specific* properties are those observed in certain bodies only, or in certain states of those bodies, as solidity, color, tenacity, etc. Physical properties may be shown without changing the identity of the molecule.
14. **Chemical Properties.**—Those resulting from the composition of the molecule with reference to its atoms and shown only with change of identity of the molecule; as combustibility, explosibility, etc.
15. **Impenetrability.**—Property of matter in virtue of which

two bodies cannot occupy the same space at the same time. Example: nail driven into wood, particles of wood make way for the nail.

16. **Extension or Magnitude.**—Property in virtue of which every body occupies a limited portion of space.

17. **Divisibility.**—Property of matter by virtue of which a body may be separated into distinct parts. Divisibility of matter practically limited *before* molecule is reached; theoretically should be limited by the atom.

18. **Porosity.**—Quality in virtue of which spaces or *pores* exist between the molecules of a body. Example: lead, if hammered, is made smaller because the size of the *pores* is reduced, the molecule being forced nearer together.

19. **Compressibility.**—Property in virtue of which a body may be reduced in size; it is a consequence and proof of porosity.

20. **Expansibility.**—Property in virtue of which a body may be increased in size. Opposite of compressibility. Example: iron when heated becomes larger or expands because its molecules are pushed further apart.

21. **Elasticity.**—Property in virtue of which bodies resume their original form or volume (size) when that form or volume has been changed by external force. Example: a piece of ordinary elastic after being stretched out, resumes its original size when the force stretching it ceases to act.

22. **Mobility.**—Property in virtue of which the position of a body may be changed. **Inertia** is the incapability of matter to change its own state of motion or rest. Example: a book on a table can not move itself and is said to have *inertia*; it can move, however, when sufficient force is applied to it and is said to have *mobility*.

23. **Cohesion.**—Force which unites molecules of the same kind, as two molecules of water or two molecules of iron. Cohesion holds substances together and gives them form.

24. **Adhesion.**—Force which unites molecules of different kinds. Example: dip a glass rod into water and on withdrawing it a drop will be found at its lower extremity which remains suspended or *adheres* to it.

25. **Hardness.**—Property in virtue of which *some* bodies resist attempts to force passage between their particles. Example: diamond possesses hardness.

26. **Brittleness.**—Property in virtue of which *some* bodies may easily be broken. Example: glass is not only hard but is also easily broken, or *brittle*.

27. **Tenacity.**—Property in virtue of which *some* bodies resist attempts to pull their particles asunder. Example: an iron wire is difficult to pull apart and is said to be *tenacious*.

Tenacity is proportional to sectional area: a rod of one inch sectional area will carry twice the load that a rod of the same material with sectional area of half a square inch will carry.

28. **Malleability.**—Property in virtue of which *some* bodies may be hammered or rolled into sheets. Example: gold can be beaten into so thin sheets that nearly 300,000 are necessary to measure an inch in height when they are placed one on another.

29. **Ductility.**—Property in virtue of which *some* bodies may be drawn into wire. Example: iron when heated may be drawn into a wire, hence is said to be *ductile*.

30. **Conditions of Matter.**—Solid, liquid, gaseous. *Fluid* is a term applied to both liquids and gases.

31. **Solid.**—A body the relative positions of whose molecules can not be changed, except with difficulty. Examples: wood, metals, etc.

32. **Liquid.**—Body whose molecules glide past each other easily but tend to cling together. Examples: water, oil, etc.

33. **Gas.**—Body whose molecules are mobile and struggle incessantly to occupy a greater volume. Example: air. *Vapors* are gases produced by heat from substances usually solid or liquid at ordinary temperatures. Example: steam.

34. **Force.**—Cause tending to produce, change or destroy motion. Example: gravity, friction, electrical or magnetic attraction, etc.

35. **Work.**—Overcoming of resistance.

36. **Energy.**—Power of doing work.

37. **Foot-pound.**—Amount of work required to raise one pound one foot high.

38. **Horse-power.**—Ability to perform 33,000 foot-pounds in a minute.

39. **Machine.**—Contrivance for utilizing energy by which power can be applied more advantageously to the resistance and in general intensity of energy be transformed.

40. **Laws of Machines.**—1. Gain in intensity of power = loss in time, velocity or distance and *vice versa*.

2.  $\text{Power} \times \text{distance} = \text{weight} \times \text{distance}$ .

3.  $\text{Power} \times \text{velocity} = \text{weight} \times \text{velocity}$ .

41. **Lever.**—Any inflexible bar, straight or curved, resting on a fixed point or edge called the *fulcrum*. Every lever has two *arms*, one each side of the fulcrum.

42. **Kinds of Levers.**—(1) fulcrum between power and resistance (weight) as in crowbar, (2) weight between power and fulcrum as in wheelbarrow, (3) power between weight and fulcrum as in the human forearm.

43. **Laws of the Lever.**—

Power  $\times$  power-arm = weight  $\times$  weight-arm.

A given power will support a weight as many times as great as itself, as the power-arm is times as long as the weight-arm.

The continued product of the power and lengths of the alternate arms beginning with the power-arm = the continued product of the weight and the lengths of the alternate arms beginning with the weight-arm.

44. **Law of Wheel and Axle.**—The power multiplied by the radius, diameter, or circumference of the wheel = the weight  $\times$  the corresponding dimension of the axle.

45. **Pulley.**—A wheel turning on an axis provided with a cord, which passes over the grooved circumference of the wheel. The axis is supported by a frame called the *block*.

46. **Inclined Plane.**—Hard, smooth, inflexible surface used in most cases to aid in the performance of work against the force of gravity. It is inclined so as to make an oblique angle with the direction of the force to be overcome and in most cases is inclined to the horizon at an acute angle.

47. **Wedge.**—Movable inclined plane in which power usually acts in a direction parallel to base. It is used for moving great weights short distances. More commonly a wedge is *two inclined planes* united at their base. With given thickness the longer the wedge the greater the gain in intensity of power.

48. **Screw.**—Cylinder with spiral groove or ridge, called the *thread*, winding about its circumference. By aid of the screw a given power will support a weight as many times greater than itself as the circumference described by the power is times as great as the distance between two adjoining turns of the thread.

49. **Friction.**—Resistance encountered by a moving body from the surface on which it moves. Is greatest at beginning of motion, increases with roughness of surfaces, greater between soft bodies than hard ones, is nearly proportional to pressure, is not affected by extent of surface within ordinary limits, is greater between surfaces of the same material than between those of different kinds; rolling friction less than sliding friction; friction diminished by polishing or lubricating the surfaces.



50. **Capillarity.**—When a glass rod is placed vertically in water the latter rises above its level at the sides of the glass, the finer the tube the greater the capillary ascent. If the rod be dipped into a liquid *which does not wet it*, as mercury, the liquid will be depressed instead of raised.

51. **Displacement.**—A body which sinks in water displaces exactly its own bulk of water and loses a weight just equal to the weight of water displaced.

52. **Specific Gravity.**—Relative weight of equal bulks of bodies referred to an assumed standard; for liquids and solids the standard is distilled water at a temperature of 4° C. or 39.2° F. For gases the standard is air or hydrogen. If a substance weighs four times as much as the same bulk of water it is said to have a sp. gr. of 4.

53. **Calculation of Specific Gravity of Solids and Liquids.**—(a) for solids use the following formula:

$$\text{Sp. gr.} = \frac{W}{W - W^1}$$

in which  $W$  = weight of body in air,  $W^1$  its weight in water (suspended by a light thread from the scale pan). Example: weight of a body in air, *i. e.*, ordinary weight, is 50 ounces; its weight in water is 42 ounces.  $W = 50$ ,  $W^1 = 42$ ,

$W - W^1 = 50 - 42$  or 8;  $\frac{W}{W - W^1} = \frac{50}{8} = 6.25$  sp. gr. In

other words the weight of the body divided by the weight of an equal volume (bulk) of water is the specific gravity of the body.

(b) If the body is lighter than water fasten a heavy body to it; weigh in air and also in water. Weigh the heavy body in water and also in air. Weigh the light body in air alone. Subtract loss of weight of heavy body from loss of weight of combined mass and divide weight of light body by the difference. Example: required to find specific gravity of a piece of cork; attach to it a piece of iron:

- |   |                       |
|---|-----------------------|
| 1. Weight of combined mass .....  | 81.5 grains           |
| 2. Weight of combined mass in water .....   | 51.5 "                |
| 3. Loss of weight of combined mass .....  | 30 "                  |
| 4. Weight of iron .....   | 76.9 "                |
| 5. Weight of iron in water .....  | 66.9 "                |
| 6. Loss of weight of iron .....   | 10 "                  |
| 7. The loss of weight of the cork will evidently be   | 30 — 10 or 20 grains. |
| 8. Weight of cork in air is 4.6 grains or   | 81.5 — 76.9.          |
| 9. Divide 4.6 (weight of light body) by 20 (loss of weight of light body) and the quotient 0.23 is the sp. gr. of the light body. |                       |

(c) To find the sp. gr. of solids which dissolve in water weigh them in some liquid in which they are insoluble and find the specific gravity as before. Multiply result by specific gravity of liquid used and the product will be the true specific gravity. Example: to find specific gravity of sugar. Suppose it weighs 10 grains in air and 4.56 grains in oil of turpentine.  $10 - 4.56 = 5.44$  grains.  $10 \div 5.44 = 1.84$  or sp. gr. referred to turpentine. Ascertain from tables the sp. gr. of turpentine ( $= 0.86$ ) multiply 1.84 by 0.86 and the product 1.58 is the true sp. gr. of the sugar.

(d) To find the specific gravity of a powder weigh a flask empty; weigh the flask full of water; weigh the flask partly full of the powder; fill the flask now containing powder full of water and weigh again. Subtract the weight of flask filled with water from weight of flask filled with powder and water mixed. *The difference will be the loss of weight of the powder.* Divide the weight of the powder in air by the loss of weight in water and the quotient will be the specific gravity of the powder.

(e) To find the sp. gr. of liquids a special flask called a picnometer or sp. gr. flask is used which contains a certain weight of water when filled. This weight is marked on the flask. To ascertain the sp. gr. of a liquid by means of its use weight it, fill it with the liquid and weigh it, subtract weight of flask, and divide difference by number marked on the flask. The quotient will be the sp. gr. of the liquid. The temperature of the liquid should be that marked on the flask.

Instruments called *hydrometers* are used for finding the sp. gr. of liquids, and are long narrow glass or metal tubes provided with a bulb near the bottom filled with air and a smaller one below it filled with mercury. To find the sp. gr. it is merely necessary to drop the hydrometer in the liquid and read off the number in the scale at the surface of the liquid.

54. **Density.** In chemistry the term density should mean the weight of a gas referred to *hydrogen* as a unit. [Specific gravity of gases means their weight referred to *air* as a unit. Thus the density of chlorine is said to be 35.5 but its specific gravity 2.47. This means that chlorine is 35.5 times as heavy as hydrogen but 2.47 times as heavy as air. In this book the term density will be used only in the case of gases. In some books the term density is used to mean specific gravity and is applied to solids].

55. **Law of Ampere.**—Equal volumes of all bodies in the state of gas, and at the same temperature and pressure, con-

tain the same number of molecules. Hence the specific gravities of any two gases are to each other as the weights of their molecules.

56. **Law of Mariotte.**—Volume of a confined gas is inversely proportional to the pressure. That is, the greater the pressure the less the volume and *vice versa*. The standard pressure is 760 millimetres or 30 inches of the barometric pressure.

57. **Law of Charles.**—Volume of a gas varies directly with the absolute temperature. That is, the cooler the gas the smaller its volume and *vice versa*. A gas expands  $\frac{1}{273}$  its volume in passing from  $0^{\circ}$  to  $1^{\circ}$  C. or  $\frac{1}{460}$  its volume for one degree Fahrenheit.

58. **Standard Temperature and Pressure.**  $0^{\circ}$  C. and 760 m.m. pressure. (See page 15.)

59. **Effects of Heat.**—In general heat expands bodies in the first place, then overcomes cohesion to such extent that body melts and becomes liquid then finally overcomes cohesion entirely and the liquid boils and passes into the gaseous state.

60. **Laws of Fusion.**—(1) Every solid begins to melt at a certain temperature which is invariable for the given substance if the pressure be constant. When cooling, the substance will solidify at the temperature of fusion. (2). The temperature of the solid, or liquid, remains at the melting point from the moment that fusion or solidification begins until it is complete.

61. **Thermal Unit.**—Amount of heat necessary to raise one pound of water from  $0^{\circ}$  C. to  $1^{\circ}$  C. or 1390 foot pounds. Sometimes applied to amount of heat necessary to raise one pound of water from  $32^{\circ}$  to  $33^{\circ}$  F. or 772 foot pounds.

62. **Boiling Point.**—Temperature at which a liquid gives off vapor rapidly from the whole liquid. Boiling point of water is  $100^{\circ}$  C. or  $212^{\circ}$  F. **Superheated** steam is the result of applying considerable pressure to a boiling liquid when its temperature will rise until the tension of the steam will overcome the pressure.

63. **Evaporation.**—Quiet formation of vapor at the surface of a liquid.

64. **Distillation.**—Conversion of a liquid into a gas and recondensation of the gas into a liquid. Operation performed in a still consisting of retort in which the liquid is boiled and a condenser for changing the vapor back to liquid.

65. **Fractional Distillation.**—Different substances boil at different temperatures. Raising the temperature of a mixture of two liquids to a point above the boiling point of one but below that of the other will vaporize the one but not the other.

66. **Destructive Distillation.**—Distillation of dry substances so as to destroy them and obtain liquids or gases. Example: coal for illuminating gas.

67. **Sublimation.**—Such solids as do not melt when heated but pass directly into vapor are said to sublime. Example: camphor.

68. **Solution.**—May be either *physical* or *chemical*.

Physical either (*a*) result of adhesion of liquid to solid overcoming the cohesion of the solid or (*b*) feeble combination of the solid with water and diffusion of this compound through remaining water. Example of (*a*) sugar dissolved in water; on boiling away the water the sugar may be recovered entirely unchanged. Example of (*b*) dried alum when dissolved in water separates again in crystals in which water is found.

Chemical, when by chemical action between two substances a soluble compound is formed, which dissolves in the water present. Example: silver forms with nitric acid by chemical action a soluble compound, silver nitrate, which then dissolves in water that may be present. Similarly an acid attacking tooth structure forms a more or less soluble compound with the lime and magnesia of the tooth.

69. **Solvents.**—All liquids are solvents.

Water is the best solvent, especially for metallic salts. Alcohol is the best solvent for resins. Mercury dissolves many metals. Gases may be dissolved in liquids. Some liquids dissolve in liquids and the process is called *liquid diffusion*.

70. **Saturated Solution.**—When a liquid has dissolved all of a solid that it can at a given temperature, the solution is called a *saturated* one.

71. **Solubility.**—The solubility of a substance is denoted by the amount of it by weight which a given amount of a solvent as water or alcohol will take up at a given temperature. Thus one part of alum is soluble in 10.5 parts of water at 59° F.

72. **Deliquescence.**—Bodies which absorb water from the air and become liquid, are said to *deliquesce*. Example: zinc chloride. Such substances are said to be *hygroscopic*.

73. **Efflorescence.**—Substances which on exposure to air lose water from their crystals, are said to effloresce. Example: ferrous sulphate, ordinary green vitriol.

74. **Dialysis.**—Liquid diffusion when liquids are separated by some porous diaphragm, as bladder or parchment paper. Passage of liquid through the diaphragm is called *Osmosis*.

75. **Dialyzer**—Glass cylinder opened at one end and closed at the other by the membrane used as separating medium.

76. **Colloids and Crystalloids**.—Easily crystallizable bodies pass through the membranes readily. Those which do not crystallize, pass through with difficulty and are called *colloids*. Examples: crystalloid, alum; colloid, gelatine.

77. **Dialysate**.—Term applied to a substance which has been dialyzed, *i. e.* has passed through the membrane of the dialyzer.

78. **Crystals**. Solid substances bounded by plane surfaces symmetrically arranged according to fixed laws. Example: diamond.

79. **Crystallization**.—Change of substances from melted state or solution to solid state with assumption of geometrical form. Essential condition, possibility of free motion of smallest particles.

80. **Amorphous—Dimorphous**.—A body never obtained in crystalline state, is said to be *amorphous*, *i. e.*, without definite form or shape; a body having two different crystalline forms is called *dimorphous*. The same body always assumes the same crystalline form under the same conditions, but under different conditions may assume different crystalline shapes. A substance is said to be *isomorphous* with another when it crystallizes in exactly the same form. Example: glue is amorphous.

81. **Water of Crystallization**.—Water taken as a necessary part of their crystals by substances separating from solutions. Amount invariable for same substance at same temperature. Example: alum has 24 molecules of water to one of alum itself and the formula of the crystal is  $K_2Al_2(SO_4)_4 \cdot 24H_2O$ .

82. **Systems of Crystals**.—Based on imaginary lines called *axes* passing through the centre of the crystal and connecting opposite angles or opposite parallel sides. For convenience six systems of crystals may be considered:

First system: axes three, at right angles, equal length; *Isometric system*. Forms: Cube, octahedron.

Second system: axes three, right angles, one longer or shorter than other two; *Tetragonal* or *Dimetric system*. Form: right square prism.

Third system: axes three, right angles, unequal lengths. *Trimetric* or *Orthorhombic system*. Forms: right rhombic prism and rhombic octahedron. Examples of third system crystals: sulphates of lead, zinc, barium, magnesium.



Fourth system: axes three, unequal, one only at right angles to plane of other two. Simplest form: oblique rhombic prism. Examples: borax, green vitriol; *Monoclinic system*.

Fifth system: axes three, all unequal, and all inclined to each other. Crystals complicated and apparently irregular: rhomboidal prism, acute and obtuse rhombohedrons. Examples: blue vitriol, boracic acid; *Triclinic system*.

Sixth system: four axes, three in one plane at angle of  $60^\circ$  to one another, fourth longer or shorter than other three at right angles to their plane. Example: quartz; *Hexagonal system*.

83. **Chemical Effects of Light.**—Many chemicals are affected by exposure to light. Solutions of several metals, among them silver and gold, throw down a part of the metal on exposure to sunlight which has certain rays capable of producing chemical changes and known as actinic rays.

84. **Electricity due to Chemical Action.**—All chemical change produces electricity. This kind of electricity is called voltaic or galvanic, and is most often developed by chemical action between liquids and metals. Example: when a strip of copper and a strip of zinc are placed in dilute sulphuric acid a current of electricity will be found to flow in a wire connecting the two strips of metal above the acid. The apparatus is called a *galvanic element* or *cell*.

85. **Current of Electricity.**—In every galvanic cell the plates and connecting wires must be conductors of electricity and the liquid used must be one which will act with greater vigor on one of the metals than on the other. The metal most actively attacked by the liquid forms the *positive* or generating plate; the other the collecting or negative plate. *The current runs in the liquid from the positive plate to the negative; in the wire connecting the plates the current runs from the negative plate to the positive.*

86. **Closed Circuit.**—When wires from the two plates are in contact. When not the circuit is *broken*.

87. **Electrodes** —Ends of the wires. Also called *poles*. The negative pole is attached to the positive plate and vice versa. Platinum strips are often fastened to the ends of wires and constitute the electrodes, and the wires are called *rheophores*.

88. **Galvanic Battery.**—A number of galvanic elements so connected that the current has the same direction in all. Usually they are connected "in series", that is, positive plate of one element with negative of the next.

89. **Forms of Cells.**—Hydrogen gas is generated by the action of an acid on a metal, and the various kinds of cells indicate the means used by their inventors to prevent the hydrogen from accumulating on the negative plate.

Potassium bichromate battery: two zinc plates having between them a carbon plate all hung in a solution of potassium bichromate in dilute sulphuric acid. To make the latter, pour 167 C.c. of sulphuric acid into 500 C.c. of water and let the mixture cool. Dissolve 115 grams of potassium bichromate in 335 C.c. of boiling water and pour while hot into the dilute acid. Let the whole cool before using. [1 gram =  $15\frac{1}{2}$  grains Troy; 30 c. c. = 1 fluid ounce]. Chromic Acid is formed, which destroys the hydrogen. Zinc plates should be removed from battery when the latter is not in use. The zincs should be *amalgamated* by first washing in dilute sulphuric acid then pouring mercury on them while still wet with the acid. Rub in the mercury well and keep a little of it in the bottom of each cell.

90. **Induced Current.**—Name given to instantaneous current produced in a conductor by the influence of a neighboring current or magnet.

91. **Faradic Battery.**—The current induced in a conductor by the influence of a neighboring current is known also as a secondary, interrupted or Faradic current. In producing it an *induction coil* is used, which is a *double* coil of wire wound around a hollow cylinder of wood. The first or *primary* coil is made of large thick copper wire covered with silk or insulated. Upon this coil and carefully insulated from it is wound the *secondary* coil of longer and thinner wire. A bundle of soft iron wires is within the inner coil to act as magnets whenever a current from a battery shall be sent through the coil. Before the end of the bundle of wires there vibrates a piece of soft iron fastened to a spring. The latter rests against a screw which connects the inner coil by a wire with a galvanic battery. When a current is sent through the inner coil an induced current is produced in the outer coil in the opposite direction and the bundle of soft iron wires is magnetized at the same time. In consequence of the latter the hammer or soft iron in the spring is drawn toward the bundle and the current is thus broken. The bundle then becomes demagnetized and the hammer is brought back to the screw by the spring, the induced current now taking the opposite direction to what it did when the hammer was in contact with the



bundle, and so on. The process is repeated as long as the current from the battery is sent through the primary coil. The induced current is therefore a *to and fro* current or a *make and break* current, the make current being in opposite direction to the break. The *break* currents are the most powerful and are reinforced by the sudden demagnetization of the bundle or core of iron wires.

92. **Electrolysis.**—Many chemical compounds in solution may be decomposed by a strong galvanic current. This process is called electrolysis. Example: if a strong galvanic current is passed through water containing a little sulphuric acid the water will be decomposed, that is, broken up into hydrogen and oxygen gases, the former being given off at the negative pole and the latter at the positive.

93. **Storage or Secondary Battery.**—One in which the polarity of the plates of a battery cell is utilized. [The polarization of the plates is caused by the accumulation of oxygen (negative) on the zinc (positive) plate and of hydrogen (positive) on the carbon (negative) plate. Owing to the layers of gas on each plate a new or secondary current is developed, for the gases are joined together by the same wires as the plates. The secondary current is often strong enough to impair the efficiency of the battery and various methods have been devised to prevent the accumulation of hydrogen].

In storage batteries the cell contains two or more large plates of sheet lead and the liquid used is dilute sulphuric acid. A current is passed through the battery and hydrogen gas accumulates on one plate and oxygen on the other. Disconnect the charging battery and a current in the opposite direction may now be obtained from the polarized cell. Storage batteries are used by dentists to furnish motive power for the drill.

94. **Galvanic Electricity in the Mouth.**—Unpleasant sensations, from a disagreeable taste up to a slight shock, are sometimes experienced by those having metal in the mouth either in form of fillings or in teeth-plates. This is due to the development of galvanic electricity by contact with some other metals, as when pins, needles, metallic tooth-picks, etc. are touched to the fillings or when the clasps or plates of artificial dentures come in contact with fillings, under peculiar conditions of oral fluids.

#### 95. **American Weights and Measures.**—

60 minims (m.) make 1 fluidrachm.....	f℥
8 fluidrachms make 1 fluidounce.....	f℥

16 fluidounces	make 1 pint.....	O.
8 pints	make 1 gallon.....	Cong.

## APOTHECARIES' WEIGHT.

20 grains (gr.)	make 1 scruple.....	sc. or ʒ
3 scruples	make 1 drachm.....	dr. or ʒ
8 drachms	make 1 ounce.....	oz. or ʒ
12 ounces	make 1 pound.....	lb. or lb

## SCALE.

lb.		oz.		dr.		sc.		gr.
1	=	12	=	96	=	288	=	5760
		1	=	8	=	24	=	480
				1	=	3	=	60
						1	=	20

## TROY WEIGHT.

24 grains (gr.)	make 1 pennyweight.....	dwt.
20 pennyweights	make 1 ounce.....	oz.
12 ounces	make 1 pound.....	lb.

## SCALE.

lb.		oz.		dwt.		gr.
1	=	12	=	240	=	5760
		1	=	20	=	480
				1	=	24

## AVOIRDUPOIS WEIGHT.

16 drachms (dr.)	make 1 ounce.....	oz.
16 ounces	make 1 pound.....	lb.
25 pounds	make 1 quarter.....	qr.
4 quarters	make 1 hundredweight.....	cwt.
20 hundredweight	make 1 ton.....	T.

## SCALE.

T.		cwt.		qr.		lb.		oz.		dr.
1	=	20	=	80	=	2000	=	32000	=	512000
		1	=	4	=	100	=	4000	=	25600
				1	=	25	=	400	=	6400
						1	=	16	=	256
								1	=	16

## 96. Metric Equivalents.—

## WEIGHT.

Unit of measurement.	Approximate equivalent.	Accurate equivalent.
1 gramme.....	15½ grains.....	15.432
1 grain ..	0.064 gramme.....	0.064
1 kilogramme (1000 grammes).....	2 1 5 pounds, avoirdupois...	2.204
1 pound, avoirdupois.....	½ kilogramme...	0.453
1 ounce, avoirdupois (437½ grains).....	28½ grammes.....	28.349
1 ounce, troy or apothecary (480 gr.).....	31 grammes.....	31.103

## BULK.

1 cubic centimetre.....	0.06 cubic inch.....	0.061
1 cubic inch.....	16½ cubic centimetres.....	16.386
1 litre (1000 cubic centimetres).....	1 U. S. standard quart.....	0.946
1 United States quart.....	1 litre.....	1.057
1 fluidounce.....	29½ cubic centimetres.....	29.570

## LENGTH.

Unit of measurement.	Approximate equivalent.	Accurate equivalent.
1 inch.....	$2\frac{1}{2}$ centimetres.....	2.539
1 centimetre (1-100 metre).....	0.4 inch.....	0.393
1 yard.....	1 metre.....	0.914
1 metre (39.37 inches).....	1 yard.....	1.093
1 foot.....	30 centimetres.....	30.479
1 kilometre (1000 metres).....	$\frac{5}{8}$ mile.....	0.621
1 mile.....	$1\frac{1}{2}$ kilometres.....	1.609

## SURFACE.

1 hectare (10,000 square metres)....	$2\frac{1}{2}$ acres.....	2.471
1 acre.....	2.5 hectare....	0.404

(Popular Science News.)

Suppose we are directed to use 175 grammes of chlorate of potassium, how much is it in ounces? We see by the table that one ounce equals 31 grammes; divide 175 by this, and we have 5.6, the required number of ounces. If we wish to measure 53 cubic centimetres of any liquid,  $53 \div 29.5$ , the number of cubic centimetres in one fluidounce = 1.8 fluidounces, the required amount. Conversely, suppose we have a quantity of some chemical weighing three-quarters of a pound, and wish to find the metric equivalent. As one pound is equal to .453 kilogramme, three-quarters of a pound will be equal to three-quarters of that weight, or .33975 of a kilogramme; or, as one kilogramme equals 1000 grammes, three-quarters of a pound will equal 339.75 grammes.

1. To convert troy grains into centigrammes, multiply by 6.
2. To convert centigrammes into troy grains, divide by 6.
3. To convert troy grains to milligrammes, multiply by 60.
4. To convert milligrammes to troy grains, divide by 60.
5. To convert troy grains to grammes or minims into fluidgrammes, divide by 15.
6. To convert grammes into grains or fluidgrammes into minims, multiply by 15.
7. To convert drachms into grammes or fluidrachms into fluidgrammes, multiply by 4.
8. To convert grammes into drachms or fluidgrammes into fluidrachms, divide by 4.

97. **Thermometry.**—The Centigrade thermometer has its zero at the freezing point and its boiling point at  $100^{\circ}$ , the number of intervening degrees being 100. One degree Centigrade equals  $1.8^{\circ}$  of Fahrenheit. To convert Centigrade to Fahrenheit multiply by 1.8 and add 32. To convert Fahrenheit to Centigrade subtract 32 and multiply by  $\frac{5}{9}$ .

## COMPARISON OF CENTIGRADE AND FAHRENHEIT DEGREES.

<i>Cent.</i>	<i>Fahr.</i>	<i>Cent.</i>	<i>Fahr.</i>	<i>Cent.</i>	<i>Fahr.</i>	<i>Cent.</i>	<i>Fahr.</i>
— 40 —	40.0	— 5 +	23.0	+ 30 +	86.0	+ 65 +	149.0
39	38.2	4	24.8	31	87.8	66	150.8
38	36.4	3	26.6	32	89.6	67	152.6
37	34.6	2	28.4	33	91.4	68	154.4
36	32.8	— 1	30.2	34	93.2	69	156.2
35	31.0	0	32.0	35	95.0	70	158.0
34	29.2	+ 1	33.8	36	96.8	71	159.8
33	27.4	2	35.6	37	98.6	72	161.6
32	25.6	3	37.4	38	100.4	73	163.4
31	23.8	4	39.2	39	102.2	74	165.2
30	22.0	5	41.0	40	104.0	75	167.0
29	20.2	6	42.8	41	105.8	76	168.8
28	18.4	7	44.6	42	107.6	77	170.6
27	16.6	8	46.4	43	109.4	78	172.4
26	14.8	9	48.2	44	111.2	79	174.2
25	13.0	10	50.0	45	113.0	80	176.0
24	11.2	11	51.8	46	114.8	81	177.8
23	9.4	12	53.6	47	116.6	82	179.6
22	7.6	13	55.4	48	118.4	83	181.4
21	5.8	14	57.2	49	120.2	84	183.2
20	4.0	15	59.0	50	122.0	85	185.0
19	2.2	16	60.8	51	123.8	86	186.8
18 --	0.4	17	62.6	52	125.6	87	188.6
17 +	1.4	18	64.4	53	127.4	88	190.4
16	3.2	19	66.2	54	129.2	89	192.2
15	5.0	20	68.0	55	131.0	90	194.0
14	6.8	21	69.8	56	132.8	91	195.8
13	8.6	22	71.6	57	134.6	92	197.6
12	10.4	23	73.4	58	136.4	93	199.4
11	12.2	24	75.2	59	138.2	94	201.2
10	14.0	25	77.0	60	140.0	95	203.0
9	15.8	26	78.8	61	141.8	96	204.8
8	17.6	27	80.6	62	143.6	97	206.6
7	19.4	28	82.4	63	145.4	98	208.4
— 6 +	21.2	+ 29 +	84.2	+ 64 +	147.2	99	215.2
						+ 100 +	212.0
110 +	230	+ 210 +	410	+ 310 +	590	+ 410	770
120	248	220	428	320	608	420	788
130	266	230	446	330	626	430	806
140	284	240	464	340	644	440	824
150	302	250	482	350	662	450	842
160	320	260	500	360	680	460	860
170	338	270	518	370	698	470	878
180	356	280	536	380	716	480	896
+ 190	374	290	554	390	734	490	914
+ 290 +	392	+ 300 +	572	+ 400	752	+ 500 +	932
+ 500 +	932	+ 800	1472	+ 1100 +	2012	+ 1400 +	2552
600	1112	+ 900 +	1632	1200	2192	1500	2732
+ 700 +	1292	+ 1000 +	1832	+ 1300 +	2372	+ 1600 +	2912

## CHAPTER II.

### HOW TO READ AND WRITE THE NECESSARY INORGANIC CHEMICAL FORMULÆ.

98. **Symbols.**—In order to read and write the chemical formulæ for the various substances of interest to the dentist, certain abbreviations must be learned, and certain tables committed to memory.\* When this has been done, the beginner, by the use of certain rules, hereafter to be given, can become familiar with the use of formulæ in a very short time.

First, commit to memory the abbreviations, called symbols, in the following tables; only those of special importance are given in Tables I and II:

TABLE I—NON-METALS.

English Name.	Symbol.	Nature.
Oxygen.....	O.....	Gas.
Sulphur.....	S.....	Solid.
Nitrogen.....	N.....	Gas.
Fluorine.....	Fl.....	Gas.
Chlorine.....	Cl.....	Gas.
Bromine.....	Br.....	Liquid.
Iodine.....	I.....	Solid.
Selenium.....	Se.....	Solid.
Phosphorus.....	P.....	Solid.
Arsenic.....	As.....	Solid.
Chromium.....	Cr.....	Solid.
Molybdenum ..	Mo.....	Solid.
Boron.....	B.....	Solid.
Carbon.....	C.....	Solid.
Antimony.....	Sb.....	Solid.
Tellurium.....	Te.....	Solid.
Silicon .....	Si.....	Solid.
Hydrogen.....	H.....	Gas.

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\* In the author's experience as a teacher, six lectures have been enough in which to teach persons of ordinary intelligence the use of the more common formulæ.

TABLE II—METALS.

English Name.	Symbol.	English Name.	Symbol.
Gold.....	Au	Nickel.....	Ni
Osmium.....	Os	Iron.....	Fe
Iridium.....	Ir	Zinc.....	Zn
Platinum.....	Pt	Manganese.....	Mn
Palladium.....	Pd	Aluminum.....	Al
Mercury.....	Hg	Magnesium.....	Mg
Silver.....	Ag	Calcium.....	Ca
Copper.....	Cu	Strontium.....	Sr
Bismuth.....	Bi	Barium.....	Ba
Tin.....	Sn	Lithium.....	Li
Lead.....	Pb	Sodium.....	Na
Cadmium.....	Cd	Potassium.....	K
Cobalt.....	Co		

Of the symbols given above, the following table will explain the origin of the most difficult:

TABLE III—LATIN NAMES OF THE ELEMENTS.

English Name.	Latin Name.
Antimony.....	Stibium.
Gold.....	Aurum.
Mercury.....	Hydrargyrum.
Silver.....	Argentum.
Copper.....	Cuprum.
Tin.....	Stannum.
Lead.....	Plumbum.
Iron.....	Ferrum.
Sodium.....	Natrium.
Potassium.....	Kalium.

99. **Definitions—Molecule, Atom, Element, Compound.**—The chemist calls the substances in Tables I, II, III, *Elements*. To understand what an element is, first study the meaning of the terms Mass, Molecule, Atom.

*Matter* or substance is the general term given to that which exists. Any portion of matter which we perceive by the sense is called a *mass* of matter. Every mass of matter consists of molecules. A *Molecule* is the smallest particle into which any substance can be divided without losing its identity as that substance. The smallest particle into which common salt can be divided and still be salt and nothing but salt is termed a molecule of salt. The smallest particle of iron which can exist free, that is, uncombined with anything else, is called a molecule of iron. Molecules are too small to be seen even with the aid of the most powerful microscope. Their existence, however, is now very generally admitted, as we are able to account for numerous phenomena if we assume that molecules exist. When a substance loses its identity its molecules

split up into smaller particles called *atoms*, which, however, have an attraction for one another and tend to form new molecules by coming together in groups. Thus, the molecule of mercuric oxide is composed of an atom of mercury combined with an atom of oxygen; when this substance is heated its molecules break up, and the substance is no longer the oxide of mercury, but mercury and oxygen. When the molecules of oxide of mercury split up, the constituent atoms re-arrange themselves, those of the mercury forming molecules of mercury, and those of oxygen molecules of oxygen.

The molecule, then, is composed of atoms, held together by a certain attraction called by some *chemism*, by others *chemical affinity*. Each atom has an attractive power for other atoms, which is definite in quantity but neutralized when a sufficient number of other atoms approach it.

**Definition 1.** A **molecule** is the smallest particle of any substance which can exist by itself and remain free and uncombined. Molecules are destructible and divisible.

**Definition 2.** An **Atom** is the still smaller particle entering into the composition of the molecule. Atoms cannot in all probability, remain free and uncombined; they are indestructible and indivisible.

It follows from definition 2, that matter is indestructible.

**Definition 3. Element:** A substance whose molecules are composed of the same kind of atoms, as the molecules of iron; the molecules of any substance in tables I, II, III are composed of atoms of that substance, and of nothing else.

**Definition 4. Compound:** A substance whose molecules are composed of different kinds of atoms. The molecule of salt is not composed of atoms of sodium alone or of chlorine alone, but an atom of sodium and an atom of chlorine.

100. **Number of Atoms in Molecules of Elements.**—At ordinary temperatures most of the elements given in tables I, II, III contain two atoms in the molecule and are called therefore, *Diatomic*. **Exceptions:** Mercury, cadmium, zinc, barium are **Monatomic**, *i. e.*, have one atom in the molecule; ozone contains three atoms of oxygen; the molecule of phosphorus and of arsenic contains four atoms: that of sulphur six, but at high temperatures, two.

101. **Elemental Atoms and Molecules.**—The symbols given in tables I, II, and III should not be used to represent the elements in general, each symbol represents **one atom** of the element; thus, Zn does not represent zinc in general, but one atom



of the element zinc with the properties of that atom, namely, definite unchanging weight, and definite power of attraction for other atoms.

**Rule 1.—To Denote a Number of Atoms of an Element, Write the Symbol of the Element with the required number in Arabic Figures at the lower right hand corner of the Symbol.**— $\text{Zn}_2$  means two atoms of zinc;  $\text{H}_3$  means three atoms of hydrogen;  $\text{O}_4$  means four atoms of oxygen. Where one atom of an element is to be represented, write the symbol only.

**Rule 2.—To Denote a Molecule of an Element, Write the Symbol of that Element with the Figure 2 at its lower right hand corner.**—Exceptions: write the symbols only of mercury, cadmium, zinc, and barium; write *four* after the symbols of phosphorus and arsenic, and *six* after sulphur.  $\text{O}_2$  means one molecule of oxygen, composed of two atoms.  $\text{Hg}_2$  means one molecule of mercury, composed of one atom;  $\text{P}_4$  means one molecule of phosphorus, composed of four atoms;  $\text{S}_6$  means one molecule of sulphur composed of six atoms. (See 100 for Atomicity).

**Rule 3. To Denote a Number of Molecules of an Element, Write the Required Number as full sized Figure before the expression for one Molecule.**  $2\text{O}_2$  means two molecules of oxygen, each composed of two atoms.  $2\text{Zn}$  means two molecules of zinc, each composed of one atom.

**102. Quantivalence.**—Before giving any rules for denoting molecules of compounds it is advisable to explain that property of atoms known as **Quantivalence**. By this term we mean the quantity of attracting and combining power which an atom of an element has. For example, chemical analysis of a number of compounds containing hydrogen shows that the different elements do not combine with it in the same proportions. An atom of bromine attracts and combines with itself *one* atom of hydrogen, but one atom of oxygen attracts and combines with itself *two* atoms of hydrogen, one of nitrogen with three, one of carbon with four, and so on. Similarly when molecules are broken up one atom of chlorine in a new molecule will take the place of one atom of hydrogen in the old; one atom of oxygen that of two of hydrogen and so on.

The equivalence or quantivalence of an atom of an element is expressed as 1, 2, 3, 4, 5, 6 or 7, according as the atom will attach to itself or be exchanged for 1, 2, 3, 4, 5, 6, and 7 atoms of hydrogen, or the equivalent of those atoms. If the atom combines with one atom of hydrogen or exchanges for one

atom of hydrogen it is called a **Monad**, if with two a **Dyad**, if with three a **Triad**, if with four a **Tetrad**, if with five a **Pentad**, if with six a **Hexad**, if with seven a **Heptad**. Monads are equivalent to monads, dyads to dyads, etc. Dyads are equivalent to two monads, triads to three monads, etc. One monad and one dyad together are equivalent to one triad, etc.

The following table should now be carefully committed to memory:

TABLE 4—QUANTIVALENCE.

Monads.	Dyads.	Triads.	Tetrads.	Hexads.
Chlorine.	Calcium.	Gold.	Carbon.	Chromium.
Bromine.	Barium.	Arsenic.	Silicon.	Iron.
Iodine.	Magnesium.	Phosphorus.	Tin.	Manganese.
Fluorine.	Zinc.	Antimony.	Platinum.	
Sodium.	Lead.	Nitrogen.	Aluminum.	
Potassium.	Mercury.	Boron.		
Silver.	Copper.	Bismuth.		
Hydrogen.	Sulphur.			
	Oxygen.			

Notice that those in *ine* are all monads, that the gases hydrogen, oxygen, nitrogen are monad, dyad, and triad respectively.

Monads are said to be *univalent*.

Dyads        "        "        *bivalent*.

Triads       "        "        *trivalent*.

Tetrads     "        "        *tetravalent*.

etc.,        etc.,        etc.

**Rule 4. To Express the Equivalence (Quantivalence) of an Atom place a Roman Numeral above and to the right of the Symbol.**


O<sup>II</sup> means one atom of oxygen having 2 as its quantivalence, or *equivalence* as it is often called. N<sup>III</sup> means one atom of nitrogen having 3 as its equivalence.


N. B.—Quantivalence is sometimes expressed by dashes, thus: O'', N'''; by some the points of attraction, or bonds, of an atom are expressed as follows:


Monad O— (one bond).


Dyad —O— (two bonds).

Triad —O— (three bonds)

Tetrad  (four bonds)

Pentad  (etc.)

Hexad 

Heptad 

103. **Variations in Quantivalence.**—Unfortunately for the

learner, the various elements do not always adhere to the quantivalence established in Table 4. Certain of the elements are not only of the quantivalence of Table 4, but of other quantivalence also.

This is the most difficult thing in chemical theory for the beginner to understand. It has been found by analysis that nitrogen for example is sometimes a monad, sometimes a triad and sometimes a pentad. This is because one element may form several *different* compounds with another element.

Let the student now commit to memory the following table:

TABLE 5—VARIATIONS IN QUANTIVALENCE.

*List I—Elements often either Monads, Triads or Pentads.*

Chlorine.....	I, III, V.
Bromine.....	I, III, V.
Iodine.....	I, III, V.
Nitrogen... ..	I, III, V.
Phosphorus....	I, III, V.
Arsenic.....	I, III, V.

*List II—Elements often either Triads or Pentads.*

Antimony ...	III, V.
Bismuth.....	III, V.

*List III—Elements often either Dyads or Tetrads.*

Carbon.....	II, IV.
Silicon.....	II, IV.
Tin.....	II, IV.
Lead.....	II, IV.
Platinum.....	II, IV.

*List IV—Elements often either Dyad, Tetrad, Hexad.*

Sulphur.....	II, IV, VI.
Selenium.....	II, IV, VI.

Other elements varying in quantivalence will be noticed whenever necessary. Table 5 includes the most important variations. It must be noticed that the equivalence of an atom always increases or diminishes by two; thus, chlorine may be either I, III, or V, but not I, II, or III. (See 109.)

104. **Formulæ.**—Compound molecules are represented by the symbols of the different elements forming the compound. This representation is termed a formula; thus KCl is a formula representing one atom of potassium and one atom of chlorine, the two together combining to form a compound molecule.

105. **Compound Molecules.** (*a*) **Binaries.**—Compound molecules are of two kinds: 1, Binary; 2, Ternary.

**Binary Compounds** are those whose molecule is composed of two atoms each one of a different element, as KCl.

Definition 5. A Binary Compound is one formed by the union of two different elements one of which must be positive to the other.

(Binary compounds containing radicals will be considered elsewhere.)

106. **Positive and Negative Elements.**—Before going any further the student must understand the meaning of the terms *positive* and *negative*.

When a current of electricity is passed through a chemical compound in state of solution, *i. e.*, dissolved, the compound is broken up into a *metal* and a *non-metal*. The metal collects about the negative pole and the non-metal at the positive pole. (See Tables I and II for non-metals and metals).

An element attracted to the *positive* pole is called a *negative* element; one attracted to the *negative* pole a *positive* element. Elements are not absolutely positive or negative but only relatively so, *i. e.*, with reference to one another. In Tables I and II the list of elements is so arranged that each element is negative to the one below it, and positive to the one above it. For example, suppose it be required to know which of the two elements, sulphur and oxygen, is positive to the other and which negative. Consulting Table I, it will be found that oxygen is *above* sulphur, therefore negative to it; sulphur is *below* oxygen, therefore *positive* to oxygen.

Rule 5. To name Binaries put the name of the positive element first and the name of the negative element second. Then change the termination of the negative element to *-ide*.

A compound of sulphur and potassium is named as follows:

(1) Consult Tables I and II, and find which is positive to the other. Potassium is at the bottom of the list, sulphur is above it, therefore potassium is positive to sulphur.

(2) Put the name of the positive element first, that of the negative second: thus, potassium sulphur.

(3) Change the termination of the negative one, sulphur, to *-ide*, and we have potassium sulphide.

Example 1. What do chlorine and potassium yield? Sulphur and sodium?

Answer. Potassium chloride. Sodium sulphide.

107. **Meaning of the terminations *-ic*, *-ous*, and *hypo-ous*.**—When the positive of two elements forming a compound is one of those which varies in equivalence (see Table V) this variation is indicated by the use of the terminations *-ic*, *-ous*, and *hypo-ous*.

Rule 6. To name a binary compound whose positive element is one which varies in equivalence, write the names of the elements precisely as in rule 5, but change the termination of the positive element to *-ic* if this element is in its highest equivalence, (Table V) to *-ous* if it is in its next highest and to *hypo-**-ous* if in its lowest.

A compound of tetrad tin and chlorine would be called stannic chloride; of dyad tin and chlorine, stannous chloride; of monad chlorine and oxygen, hypochlorous oxide. (Notice in Table I that oxygen is negative to chlorine).

Example 2. What do pentad chlorine and oxygen form? Triad antimony and chlorine? Monad phosphorus and oxygen?

Answer. Chloric oxide. Antimonous chloride. Hypophosphorous oxide.

Rule 7. To write the formula for a binary compound, write the symbol of the positive element first, then the symbol of the negative element. At upper right hand of symbol of positive element write the equivalence of that element; do the same to the negative. Transfer the Roman numerals indicating equivalence of positive element to lower right hand of negative element. Transfer the Roman numerals indicating equivalence of the negative element to the lower right hand of positive element. Write all transferred numerals in Arabic figures, changing them from Roman. (See also Remark I).

To write the formula for stannic chloride:

- |                                 |   |
|---------------------------------|---|
| (1) Symbol of positive element, | Sn;   |
| (2) Symbol of negative element, | Cl;   |
| (3) Arranged in order,          | SnCl;   |
| (4) Equivalence indicated,      | $\overset{\text{IV}}{\text{Sn}}\overset{\text{I}}{\text{Cl}}$ ; |
| (5) Numerals transferred,       | $\text{SnCl}_4$ .   |

N. B.—It is really never necessary to write the figure 1 as the symbol itself indicates one atom.

108. If several molecules of the binary compound are to be denoted, write the formula, inclose in brackets, and write the multiplier as a small-sized figure at lower right hand, or write a full sized figure before the formula not enclosed in brackets.

Suppose it be required to denote 3 molecules of sodium iodide: the formula is NaI and this formula denotes *one molecule* with all the properties of that molecule, namely, a certain unchangeable weight—the sum of the weights of the two atoms, called the molecular weight—or, in the case of gases, a certain volume always the same; to denote 3 mole-

cules write the figure 3 before the formula thus:  $3\text{NaI}$ , or bracket the formula ( $\text{NaI}$ ) and write the figure 3 in small-sized type at the lower right hand; thus,  $(\text{NaI})_3$ .

Example 6. Denote five molecules of magnesium oxide, six of silver chloride, three of chlorous oxide.

Answer.  $5\text{MgO}$  or  $(\text{MgO})_5$ ,  $6\text{AgCl}$  or  $(\text{AgCl})_6$ ,  $3\text{Cl}_2\text{O}_3$  or  $(\text{Cl}_2\text{O}_3)_3$ .

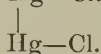
*Remark.* In order to apply rule 7 successfully the following must be borne in mind: if a formula, obtained by rule 7, shows after each atom figures which contain common factors, these common factors must be removed from the figures; thus, the formula for stannic oxide, according to rule 7, is  $\text{Sn}_2\text{O}_4$ ; but 2 and 4 contain the common factor 2, therefore divide each by 2 and the result  $\text{SnO}_2^*$  is the proper formula.

Example 7. Write the formulæ for platinic sulphide, hypsulphurous oxide, selenic oxide, stannous sulphide:

Answer.  $\text{PtS}_2$ ,  $\text{SO}$ ,  $\text{SeO}_3$ ,  $\text{SnS}$ .

109. **Variation in Equivalence of Certain Elements.**—Certain elements vary in equivalence in a puzzling manner, e. g. mercury, copper, iron, aluminum. As compounds of these metals are important, it is desirable that the variations in equivalence be thoroughly understood.

Mercury is a dyad, according to table 4; in some compounds, however, we find two atoms of mercury and two of a monad, as for example in calomel, the formula for which is  $\text{Hg}_2\text{Cl}_2$ . The formula  $\text{Hg}_2\text{Cl}_2$  is explained by the graphic formula:



Two atoms of dyad mercury would have four bonds and ought to take four atoms of monad chlorine, but two of the bonds of the mercury satisfy each other instead of requiring two bonds of chlorine; the other two bonds of the mercury are satisfied by means of two chlorine bonds, hence  $\text{Hg}_2\text{Cl}_2$ , and not  $\text{Cl}_4$ , as would be expected. (Variation in equivalence may, in general, be explained by graphic formulæ). The same may be said of copper. Such compounds are called mercurous or cuprous compounds.

Rule 9. To write formulæ containing mercury or copper, assign to mercuric atoms and cupric atoms an equivalence of *two* as in table 4; to mercurous and cuprous assign an equivalence

---

\* $\text{Sn}_2\text{O}_4$  is the same as  $2\text{SnO}_2$  or  $(\text{SnO}_2)_2$ , the true formula being  $\text{SnO}_2$ .



of *one*. N. B. In the case of mercurous and cuprous note that two atoms of mercury or copper require two only of a monad element.

Example 8. Write the formulæ for mercuric chloride, mercurous iodide, cupric oxide, mercurous chloride.

Answer.  $\text{HgCl}_2$ ,  $\text{HgI}$  or  $\text{Hg}_2\text{I}_2$ ,  $\text{CuO}$ ,  $\text{HgCl}$  or  $\text{Hg}_2\text{Cl}_2$ .

Compounds of iron are known in which the molecule may consist of two atoms of iron and six of a monad as, for example ferric chloride,  $\text{Fe}_2\text{Cl}_6$ ; to such compounds the term *ferric* is applied.

Rule 10. To write formulæ containing *iron*, give two atoms of iron an equivalence, together, of six, if the compound is called ferric. In ferrous compounds assign equivalence of two to iron.

N. B. While  $\text{Hg}_2\text{Cl}_2$  is often written in the simpler form  $\text{HgCl}$ , it is not customary to write  $\text{Fe}_2\text{Cl}_6$  in any simpler fashion; the formulæ of other compounds may be simplified.

Example 9. Write the formulæ for ferric chloride, ferric oxide, ferrous sulphide, ferrous oxide, aluminic chloride.

Answer.  $\text{Fe}_2\text{Cl}_6$ ,  $\text{Fe}_2\text{O}_3$ , [that is  $(\text{Fe}_2)_2\text{O}_6$ ],  $\text{FeS}$ ,  $\text{FeO}$ ,  $\text{Al}_2\text{Cl}_6$ .

Rule 11. To read Binary formulæ, observe from figure at lower right hand of negative element what the equivalence of the positive element is. If the positive element is in its highest equivalence (Table V) change its termination to -ic etc., as in Rule 6. Note that where sulphur or selenium is the positive element and the negative element oxygen, the figure 3 at the lower right hand of oxygen will denote sulphur or selenium as a hexad, hence sulphuric, e. g.,  $\text{S}_2\text{O}_6$  or  $\text{SO}_3$  is sulphuric oxide.

The termination of the negative element is always changed to -ide, in reading binary formulæ.

Example 10. Read the formulæ of the following compounds used in dental medicine:

1,  $\text{KBr}$ . 2,  $\text{KI}$ . 3,  $\text{HCl}$ . 4,  $\text{SnCl}_2$ . 5,  $\text{KCl}$ . 6,  $\text{K}_2\text{O}$ . 7,  $\text{H}_2\text{O}$ . 8,  $\text{Al}_2\text{Cl}_6$ . 9,  $\text{As}_2\text{O}_3$ . 10,  $\text{AuCl}_3$ . 11,  $\text{HgCl}_2$ . 12,  $\text{HgCl}$ . 13,  $\text{HgI}$ . 14,  $\text{ZnI}_2$ . 15,  $\text{ZnO}$ . 16,  $\text{MgO}$ . 17,  $\text{CaO}$ .

Answer. 1, potassium bromide. 2, potassium iodide. 3, hydrogen chloride. 4, stannous chloride. 5, potassium chloride. 6, potassium oxide. 7, hydrogen oxide. 8, aluminic chloride (see Rule 10). 9, arsenious oxide. 10, auric chloride. 11, mercuric chloride. 12, mercurous chloride (see Rule 9). 13, mercurous iodide. 14, zinc iodide. 15, zinc oxide. 16, magnesium oxide. 17, calcium oxide.



Example 11. Read the following formulæ (of use in studying ternaries):  $\text{Cl}_2\text{O}_5$ ,  $\text{N}_2\text{O}_5$ ,  $\text{SO}_3$ ,  $\text{SO}$ ,  $\text{Cl}_2\text{O}$ ,  $\text{Cl}_2\text{O}_3$ ,  $\text{CO}_2$ .

Answer. Chloric oxide, nitric oxide, sulphuric oxide, hypsulphurous oxide, hypochlorous oxide, chlorous oxide, carbonic oxide.

#### 110. Ternary Compounds.—

Definition 6. A ternary compound is one whose molecule is composed of three or more different kinds of atoms: thus,  $\text{KClO}_3$  is a ternary because composed of K, Cl, and O. In every ternary formula there are three different symbols.

There are three kinds of ternaries: acids, bases, and salts.

Definition 7. Acids are corrosive substances having usually a sour taste, neutralizing alkalies, and changing blue vegetable colors to red. They give off hydrogen when brought in contact with a metal. Acids are either (hydracids) ox-acids, or sulph-acids. [Hydracids are binary compounds of hydrogen and are hydrochloric,  $\text{HCl}$ ; hydrobromic,  $\text{HBr}$ ; hydriodic,  $\text{HI}$ ; hydrosulphuric,  $\text{H}_2\text{S}$ . They are also called hydrogen (or hydric) chloride, hydrogen or hydric bromide, etc.]

Ox-acids are composed of hydrogen, some non-metal, and oxygen: as  $\text{HNO}_3$ , nitric acid.

Sulpho-acids are composed of hydrogen, some non-metal, and sulphur, as  $\text{H}_2\text{CS}_3$ , sulpho-carbonic acid.

Rule 12. To write the formulæ of many ox-acids and sulpho-acids:

1. Write the formula of corresponding oxide or sulphide, simplifying if possible.
2. Add formula for a molecule of water,  $\text{H}_2\text{O}$ .
3. Simplify if possible.

Suppose the formula for nitric acid be required; first write the formula for the corresponding oxide. By this we mean nitric\* oxide and not nitrous nor hyponitrous. Formula for nitric oxide is  $\text{N}_2\text{O}_5$ ; add  $\text{H}_2\text{O}$  and we have  $\text{H}_2\text{N}_2\text{O}_6$ —the only thing to be added arithmetically being O to  $\text{O}_5$  making  $\text{O}_6$ . Now simplify by taking out the common factor 2 and we have  $\text{HNO}_3$ . (See also table 6 and note rule 15, page 29).

Note. The formulæ for phosphoric, boric, arsenic, arsenious, and hypophosphorous acids is obtained by adding more than one molecule of water or by table 6, page 28.

Example 12. Write the formulæ for the following acids: sulpho-carbonic, sulphuric, sulphurous, hypochlorous.

---

\*This rule gives always hydrated acids and is of service in obtaining formulæ of salts.

Answer.  $\text{H}_2\text{CS}_3$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{SO}_3$ ,  $\text{HClO}$ .

N. B. The oxygen or sulphur of acids is said to have a linking function, uniting the hydrogen to the rest of the molecule: thus, the formula for nitric acid may be represented graphically as follows:

$\text{H}-\text{O}-\text{N}=\text{O}$  } the hydrogen atom being linked to the rest  
 $=\text{O}$  { of the molecule by the oxygen atom.

Definition 8. **Bases** are the opposite of acids. They neutralize either partly or entirely the acids, restore blue color to vegetable colors turned red by acids, and, in concentrated form, decompose fats, forming soap, and act on the tissues as caustics.

Acids unite with metals to form salts, bases with acids to form salts, hydrogen being involved in the one case, water formed in the other.

Inorganic bases are termed hydrates, by which term we shall hereafter call them. The molecule of a hydrate is composed of a positive atom, hydrogen, and oxygen; thus,  $\text{X O H}$ .

The oxygen of bases is said to link the hydrogen to the positive element.

The formula for sodium hydrate may be represented graphically as follows:  $\text{Na}-\text{O}-\text{H}$ , in which the positive atom is linked by the atom of oxygen to the hydrogen.

Rule 13. **To write the formula for a hydrate**, first write the symbol of the positive element with its equivalence over it, then write  $[\text{OH}]$  in brackets with an equivalence of 1 over it. Next exchange figures representing equivalences, as in binaries.

To write the formula for calcium hydrate:

1.  $\text{Ca}^{\text{II}}$ .
2.  $(\text{OH})^1$ .
3.  $\text{Ca}^{\text{II}}(\text{OH})^1$ .
4.  $\text{Ca}(\text{OH})_2$ . Calcium hydrate.

Calcium hydrate represented graphically would be  $\text{Ca} \begin{smallmatrix} \diagup \text{OH} \\ \diagdown \text{OH} \end{smallmatrix}$

Example 13. Write the formulæ for barium hydrate, mercuric hydrate, arsenious hydrate, cuprous hydrate.

Answer.  $\text{Ba}(\text{OH})_2$ ,  $\text{Hg}(\text{OH})_2$ ,  $\text{As}(\text{OH})_3$ ,  $\text{CuOH}$ .

N. B. Where one molecule only of  $\text{OH}$  occurs it is not necessary to bracket. Instead of  $\text{OH}$  some authors write  $\text{HO}$ .

Definition 9. A **salt** resembles neither an acid nor a base; its molecule consists of a positive atom united by oxygen to a negative atom; thus,  $\text{KNO}_3$ : K, positive atom, N negative, O oxygen.

Exceptions. A salt may be formed from an acid and a metal by the latter replacing the hydrogen of the acid; acids whose molecule contains two atoms of hydrogen may not always exchange both atoms for atoms of a metal, but one may be replaced and the other not: thus,  $\text{NaHSO}_4$ . Such a salt is called an *acid* salt. Those described in definition 9, are called *normal* salts. *Double* salts are those whose molecules consists of two different positive atoms united by oxygen to the negative atom: thus,  $\text{KNaSO}_4$  called potassium sodium sulphate.

Rule 14. **To write the formula of a salt**, first write the formula of the acid which, with the metal, forms the salt; bracket the non-hydrogen part of the acid formula, erase the H, and put in its place the symbol of the metal; write the equivalence of the metal after the bracket, and simplify if possible.

Note that *-ate* in a salt corresponds to *-ic* in an acid, *-ite* to *-ous*, etc.

Suppose the formula for mercuric nitrate be required. The termination *-ate* in a salt is used by chemists to signify a higher equivalence of the negative element, just as *-ic* is used in the case of acids:

1. Write the formula for nitric acid:  $\text{HNO}_3$ .
2. Bracket for non-hydrogen part:  $\text{H}(\text{NO}_3)$ .
3. Erase the H and put in its place the symbol of the metal mercury:  $\text{HgNO}_3$ .
4. Write the equivalence of metal after bracket:  $\text{Hg}(\text{NO}_3)_2$ .
5. Simplify. (Not possible in this case).

The formulæ for salts may be written much more rapidly if the following table of groups of atoms, called *compound radicals*, be committed to memory:

TABLE 6—COMPOUND RADICALS.

Monads.	Dyads.	Triads.	Tetrads.
$\text{NO}_3$ (Nitrates)	$\text{SO}_4$ (Sulphates)	$\text{PO}_4$ (Phosphates)	$\text{FeCy}_6^*$ (Ferrocyanides)
$\text{NO}_2$ (Nitrites)	$\text{SO}_3$ (Sulphites)	$\text{AsO}_4$ (Arsenates)	$\text{SiO}_4$ (Silicates)
$\text{ClO}_3$ (Chlorates)	$\text{CO}_3$ (Carbonates)	$\text{AsO}_3$ (Arsenites)	$\text{P}_2\text{O}_7$ (Pyrophosphates)
$\text{PH}_2\text{O}_2$ (Hypophosphites)	$\text{CrO}_4$ (Chromates)	$\text{BO}_3$ (Borates)	Hexads.
$\text{ClO}$ (Hypochlorites)	$\text{Cr}_2\text{O}_7$ (Bichromates)		$\text{Fe}_2\text{Cy}_{12}^*$ Ferricyanides

\*These will be explained under the head of theory of organic chemistry.

Rule 15. To write the formula of a salt by use of table 6, first write the symbol for the metal, with its equivalence indicated over it; next write the formula for the compound radical with its own equivalence over it; exchange equivalences; simplify if possible.

Suppose the formula of zinc hypophosphite be required:

1.  $\text{Zn}^{\text{II}}(\text{PH}_2\text{O}_2)^1$ .
2.  $\text{Zn}(\text{PH}_2\text{O}_2)_2$ .

N. B. Acids being regarded by some as salts of hydrogen, their formulæ may be written from Table 6: thus, sulphuric acid may be written as hydrogen sulphate:

1.  $\text{H}^1(\text{SO}_4)^{\text{II}}$ .
2.  $\text{H}_2\text{SO}_4$ .

Phosphoric acid and boric acid should be written from Table 6 altogether, as they are meta- and ortho-acids respectively, as regards their salts used in dental medicine.

Example 14. Write the formulæ for the following salts used in dental medicine: cadmium sulphate, cupric sulphate, zinc sulphate, magnesium sulphate, magnesium hypochlorite, calcium sulphite, calcium hypophosphite (by Table 6), calcium carbonate, silver nitrate.

Answer.  $\text{CdSO}_4$ ,  $\text{CuSO}_4$ ,  $\text{ZnSO}_4$ ,  $\text{MgSO}_4$ ,  $\text{Mg}(\text{ClO})_2$ ,  $\text{CaSO}_3$ ,  $\text{Ca}(\text{PH}_2\text{O}_2)_2$ ,  $\text{CaCO}_3$ ,  $\text{AgNO}_3$ .

Example 15. For practice write the formulæ of the following:

- |                          |  |
|--------------------------|--|
| 1. Cupric ferrocyanide,  | 9. Potassium hypochlorite,   |
| 2. Barium chromate,      | 10. Calcium hypochlorite,  |
| 3. Lead sulphate,        | 11. Potassium sodium sulphate,   |
| 4. Ferric sulphate,      | 12. Potassium sodium acid phosphate, or potassium sodium hydrogen phosphate. |
| 5. Ferric hypophosphite, | 13. Sodium hydrogen carbonate or sodium bicarbonate.                         |
| 6. Aluminic hydrate,     |  |
| 7. Ferrous sulphate,     |  |
| 8. Sodium hypophosphite, |  |

Answers:—

- |   |   |
|---|---|
| 1. $\text{Cu}_2\text{FeCy}_6$ ,             | 8. $\text{Na}(\text{PH}_2\text{O}_2)$ , |
| 2. $\text{BaCrO}_4$ ,                       | 9. $\text{KClO}$ ,                      |
| 3. $\text{PbSO}_4$ ,                        | 10. $\text{Ca}(\text{ClO})_2$ ,         |
| 4. $\text{Fe}(\text{SO}_4)_3$ ,             | 11. $\text{KNaSO}_4$ ,                  |
| 5. $\text{Fe}_2(\text{PH}_2\text{O}_2)_6$ , | 12. $\text{KNaHPO}_4$ ,                 |
| 6. $\text{Al}_2(\text{HO})_6$ ,             | 13. $\text{NaHCO}_3$ .                  |
| 7. $\text{FeSO}_4$ ,                        |   |

---

\*This example may, at the discretion of the teacher, be omitted.

## Rule 16.

TABLE 7—USUAL TERMINATIONS OF BINARY AND TERNARY FORMULÆ.  
BINARIES.

Hydrochloric acid and all chlorides end in  $\text{Cl}_n$ .<sup>\*</sup>  
 Hydrobromic acid and all bromides end in  $\text{Br}_n$ .  
 Hydriodic acid and all iodides end in  $\text{I}_n$ .  
 Hydrosulphuric acid and all sulphides end in  $\text{S}_n$ .  
 Hydrofluoric acid and all fluorides end in  $\text{F}_n$  or  $\text{Fl}_n$ .  
 All oxides end in  $\text{O}_n$ .

## TERNARIES.

Sulphuric acid and all sulphates end in  $(\text{SO}_4)_n$ .  
 Phosphoric acid and all phosphates end in  $(\text{PO}_4)_n$ .  
 Chromic acid and all chromates end in  $(\text{CrO}_4)_n$ .  
 Boric acid and all borates end in  $(\text{BO}_3)_n$ .  
 Nitric acid and all nitrates end in  $(\text{NO}_3)_n$ .  
 Chloric acid and all chlorates end in  $(\text{ClO}_3)_n$ .  
 Sulphurous acid and all sulphites end in  $(\text{SO}_3)_n$ .  
 All hydrates end in  $(\text{OH})_n$ .

<sup>\*</sup> $n$  denoting any number.

Hypochlorous acid and all hypochlorites end in  $\text{ClO}$ .

Hypophosphorous acid and all hypophosphites end in  $\text{PH}_2\text{O}_2$ .

Suppose now that the formula to be read be  $\text{HNO}_3$ ; it begins with H therefore is an acid; it ends in  $\text{NO}_3$ , therefore (table 7) is nitric acid. Suppose it be required to read the formula  $\text{Al}_2(\text{OH})_6$ ; it is not an acid because it does not begin with H, but is a hydrate, because it ends in OH; and it is aluminic hydrate by rule 10. Suppose the formula be  $\text{K}_2\text{CO}_3$ . It is not an acid, nor a hydrate, but is a salt because ending in oxygen preceded by a non-metal. It is carbonate by table 7, hence is potassium carbonate. Suppose the formula be  $\text{Fe}_2(\text{CrO}_4)_3$ ; it is a salt, because ending in O preceded by a non-metal, and by table 7 a *chromate*, and by rule 10, *ferric chromate*.

Example 16. Read the formulæ given in the answers to example 16.

N.B. Consideration of formulæ of organic compounds is deferred to Chap. VIII, but as a sharp line of demarcation cannot always be drawn between many inorganic and organic compounds, the beginner will do well to note the following:

## TABLE 8—ORGANIC COMPOUNDS.

## BINARIES.

Hydrocyanic acid and all cyanides end in  $\text{CN}_n$ .

Hydroferrocyanic acid and all ferrocyanides end in  $\text{FeCy}_6$ .

Hydroferricyanic acid and all ferricyanides end in  $(\text{Fe}_2\text{Cy}_{12})_n$ .

Sulphocyanic acid and all sulphocyanates end in  $(\text{CNS})_n$ .

## TERNARIES.

Acetic acid and all acetates end in  $(\text{C}_2\text{H}_3\text{O}_2)_n$ .

Oxalic acid and all oxalates end in  $(\text{C}_2\text{O}_4)_n$ .

Tartaric acid and all tartrates end in  $(\text{C}_4\text{H}_4\text{O}_6)_n$ .

Salicylic acid and all salicylates end in  $(\text{C}_7\text{H}_4\text{O}_3)_n$ .

$n$  denoting any number.

Example 17.\* Read the following formulæ:  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ ,  $\text{K}_2\text{C}_2\text{O}_4$ ,  $\text{KCN}$ ,  $\text{K}_4\text{FeCN}_6$  or  $\text{Cy}_6$ ,  $\text{KNaC}_4\text{H}_4\text{O}_6$ ,  $\text{NaCNS}$  or  $\text{CyS}$ ,  $\text{Na}_2\text{C}_7\text{H}_4\text{O}_3$ .

Answer. plumbic acetate, potassium oxalate, potassium cyanide, potassium ferrocyanide, potassium sodium tartrate, sodium sulphocyanate, sodium salicylate.

N. B. Ammonium compounds begin with  $(\text{NH}_4)$  a univalent radical: ammonium chloride is  $(\text{NH}_4)\text{Cl}$ , ammonium sulphate  $(\text{NH}_4)_2\text{SO}_4$ , etc., etc.

Example 18. Read the following:  $\text{NH}_4\text{NO}_3$ ,  $\text{NH}_4\text{HO}$ ,  $\text{NH}_4\text{MgPO}_4$ .

Answer. Ammonium nitrate, ammonium hydrate, ammonium magnesium phosphate.

111. **Nomenclature—Old and New.**—The prefixes *proto-* and *per-* are used in older works instead of *-ic* and *-ate* on the one hand and *-ous* and *-ite* on the other; for example, instead of *mercurous iodide* older writers speak of the *protiodide* of *mercury*; instead of *ferric sulphate* the *persulphate* of *iron* is the name given.

The term *acid* in some of the older books is given to what is now called *anhydride* or negative oxide; thus *arsenious acid* is used by some writers as the name for  $\text{As}_2\text{O}_3$  which in this book is called arsenious anhydride or arsenous anhydride. The term *anhydrous acid* is also used by some writers instead of anhydride or oxide, and the term *hydrated acid* for what in this book is called simply *acid*. Oxides of sodium, potassium, magnesium, etc., are called *soda*, *potassa*, *magnesia*, etc., by some authors.

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\*This example at the option of the teacher may be omitted until organic chemistry be taken up.



Example 19. Give the new names for the following: baryta, perchloride of tin, protoxide of mercury, perchloride of iron, potash, alumina, protochloride of mercury, anhydrous phosphoric acid.

Answer. Barium oxide, stannic chloride, mercurous oxide, ferric chloride, potassium oxide, aluminum oxide, mercurous chloride, phosphoric anhydride or oxide.

N. B. Remember that in modern text books the term anhydride simply means an oxide which can combine with the elements of water to produce an acid, or in other words an acid minus water.

In many new text books, notably those by English authors, we find numeral prefixes as di-, tri-, pent-, etc. Thus,  $\text{CS}_2$  is called carbon disulphide,  $\text{P}_2\text{O}_5$  phosphorus pentoxide, etc., etc. The old term for di- is bi-. Older writers use the prefix *sesqui-* in compounds where there are two atoms of one element and three of another; they also call hydrochloric acid *muriatic acid*, and term chlorides *muriates*. Sulphides are termed *sulphurets* by some.

Example 20. Give new names for the following: sesquioxide of iron, bisulphuret of carbon, sesquisulphide of iron, muriate of ammonia, bichloride of mercury, protosulphuret of iron, peroxide of hydrogen.

Answer. Ferric oxide ( $\text{Fe}_2\text{O}_3$ ), carbonic disulphide, ferric sulphide ( $\text{Fe}_2\text{S}_3$ ), ammonium chloride, mercuric chloride, ferrous sulphide, hydric dioxide.

112. **Reactions.**—The chemical action between two substances on each other when brought together is called a **reaction**. The body, which, when added to another causes the change, is called a **reagent**.

113. **Laws of Berthelet.**—1. When two or more substances are brought together in solution, if by any rearrangement of the atoms a product can be formed, insoluble in the liquid present, that substance will form and separate as a **precipitate**.

2. When two substances are brought together in solution, if a gaseous body, or one volatile at the temperature of the experiment, can form, it will form and escape as a gas or vapor.

114. **Chemical Equations.**—These represent what actually takes place in a reaction. The sum of the weights of the factors is always equal to the sum of the weights of the products.

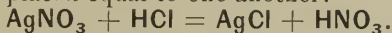


**To write Chemical Equations.—**

1. Write formulæ of factors.
2. Connect formulæ of factors by plus sign.
3. Write formulæ of products, connected by sign of plus.
4. Between factors and products write the sign =

Thus silver nitrate and hydrogen chloride give silver chloride and hydrogen nitrate; represent the reaction by an equation:

1. Formulæ of factors:  $\text{AgNO}_3, \text{HCl}$ .
2. Connected by plus sign:  $\text{AgNO}_3 + \text{HCl}$ .
3. Formulæ of products:  $\text{AgCl}, \text{HNO}_3$ .
4. Connected by plus sign:  $\text{AgCl} + \text{HNO}_3$ .
5. 2 and 4 placed equal to one another:



**Rules for determining the changes which take place in chemical reactions.**—To decide why, for example, silver nitrate and hydrogen chloride give silver chloride and hydrogen nitrate, certain rules should be committed to memory:

1. Find out which elements or radicals are positive and which negative. [In the above equation in the left hand member we find the metal, silver, positive, the radical  $\text{NO}_3$  negative. Hydrogen is positive and chlorine negative. (See tables 1 and 2, and page 1. Positives combine with negatives and vice versa, hence on the right hand side in the results, Ag will be found with Cl, and not with H, and the latter with  $\text{NO}_3$ , and not with Ag.]

2. Cause the positives to change places.

3. Pay due attention to quantivalence. [In the above equation, Ag being monad can take the place of H to form  $\text{AgCl}$ , and H being monad can take the place of Ag to form  $\text{HNO}_3$ .]

4. Notice that compound radicals usually remain unchanged in products.

5. N. B. An acid and an alkali cannot exist in the same solution, and the strongest acid usually selects the strongest base with which to combine.

**Example 21.** Complete the following equations:

1.  $\text{Zn} + \text{H}_2\text{SO}_4 = ?$
2.  $\text{BiCl}_3 + \text{H}_2\text{O} = ?$
3.  $\text{Pb}(\text{NO}_3)_2 + \text{K}_2\text{O} = ?$
4.  $\text{Zn} + (\text{HCl})_2 = ?$
5.  $\text{ZnO} + 2\text{H}(\text{C}_2\text{H}_3\text{O}_2) = ?$
6.  $3\text{H}_3\text{PO}_3 + 2\text{HNO}_3 = ?$
7.  $2\text{ZnCO}_3 + 3\text{Zn}(\text{OH})_2 = ?$

Answers.—

1.  $\text{ZnSO}_4 + \text{H}_2$ .
2.  $\text{BiOCl} + 2\text{HCl}$ .
3.  $(\text{KNO}_3)_2 + \text{PbO}$ .
4.  $\text{ZnCl}_2 + \text{H}_2$ .
5.  $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{H}_2\text{O}$ .
6.  $3\text{H}_3\text{PO}_4 + \text{N}_2\text{O}_2 + \text{H}_2\text{O}$ .
7.  $5\text{ZnO} + 2\text{CO}_2 + 3\text{H}_2\text{O}$ .

Notes: In No. 1, the zinc being a dyad replaces  $\text{H}_2$ , which being a gas escapes as such according to Berthelet's second law. In No. 2, Bi being a triad can not combine with oxygen, a dyad, alone to form  $\text{BiO}$ , but retains one atom of Cl, and takes one atom of oxygen in addition, hence  $\text{BiOCl}$ . It is not  $\text{BiOH}$  instead of  $\text{BiOCl}$ , because then H and  $\text{Cl}_2$  would be left to unite, whereas H must unite with Cl and not with  $\text{Cl}_2$ ; moreover Bi is positive and must unite with negatives. In No. 3, Pb being a dyad can exchange for  $\text{K}_2$ . In No. 4, Zn being a dyad can exchange with  $\text{H}_2$ , the latter being set free as in 1. In No. 5 the radical  $\text{C}_2\text{H}_3\text{O}_2$  is unchanged in the product. In No. 6 the only change which takes place is the taking of three atoms of oxygen away from  $2\text{HNO}_3$  leaving  $\text{H}_2\text{N}_2\text{O}_3$ , which splits up into  $\text{N}_2\text{O}_2$  and  $\text{H}_2\text{O}$ . In this example it is necessary to write the  $2\text{HNO}_3$  as  $\text{H}_2\text{N}_2\text{O}_6$ . In No. 7 rewrite as  $\text{Zn}_5\text{C}_2\text{O}_{12}\text{H}_6$ , and the 5 ZnO withdrawn leaves  $\text{C}_2\text{O}_7\text{H}_6$ , out of which if water  $\text{H}_2\text{O}$  is to be taken it will come as  $\text{H}_6\text{O}_3$  or  $3\text{H}_2\text{O}$ , leaving  $\text{C}_2\text{O}_4$  or  $2\text{CO}_2$ .

**How substances act:**—A knowledge of the principles of chemical reactions is of great importance in studying the action of substances on one another: for example the solution of silver in nitric acid, and the throwing down of the silver again by hydrochloric acid may be represented as follows:  $2\text{Ag} + 2\text{HNO}_3 = 2\text{AgNO}_3 + \text{H}_2$ ; then  $\text{AgNO}_3 + \text{HCl} = \text{AgCl} + \text{HNO}_3$ . The action of an acid on the mineral matters in a tooth is like the former.

**115. Chemical Arithmetic.**—By use of equations we may calculate the weight of any substance required by any given process. The rule is, as the formula of the given substance is to the formula of the required substance so is the weight of the given substance to the weight of the required substance. Thus, how much sulphate of zinc can be made from 5 pounds of zinc?

Reaction:  $\text{Zn} + \text{H}_2\text{SO}_4 = \text{ZnSO}_4 + \text{H}_2$ .

Proportion:  $\text{Zn} : \text{ZnSO}_4 : 5 : \text{X}$ .

Reduced to figures: 65 : 161 :: 5 : X.

atomic wt.    molecular wt.  
of zinc.    zinc sulphate.

Algebraically:  $65\text{X} = 161 \times 5$

$$\text{X} = \frac{161 \times 5}{65} = \frac{161}{13} = 12.3 \text{ pounds.---Ans.}$$

Note. After the formulæ are written in the proportion the molecular weights are substituted for them.

## CHAPTER III.

### NON-METALLIC ELEMENTS.

116. The non-metallic elements are oxygen, hydrogen, nitrogen, carbon, boron, silicon, sulphur, phosphorus, antimony, arsenic, chlorine, bromine, iodine, fluorine.

N. B. For sake of convenience, antimony will be considered among the metals, and arsenic among the metals whose compounds are of importance in dental medicine.

[For table of non-metals and their properties see page 40.]

117. **Non-Metals.**—Use in dentistry.

**Oxygen.**—A body is called “combustible” when it unites readily with oxygen, heat and light being at the same time liberated. It is the oxygen in the air which supports combustion, and which affords us our artificial heat and light. Substances which burn with difficulty in the air, owing to the latter not being pure oxygen, but a mixture of oxygen with nitrogen, will burn in pure oxygen with great readiness. Oxygen blowpipes are those in which the flame is blown with a jet of oxygen; oxyhydrogen blowpipes, those where the hydrogen burns in a stream of oxygen gas, producing a heat which fuses refractory substances such as flint, quartz, etc., and melts the various metals. Some metals, as platinum, which can not be fused in a furnace may be melted by the oxyhydrogen flame.

118. **Hydrogen.**—This gas made by the action of an acid on some metal, as zinc, is used with the oxyhydrogen blowpipe.

119. **The Atmosphere.**—Under the head of oxygen and nitrogen, air must be considered, which is not a *compound*, but when pure is a *mixture* of 20.93 parts of oxygen by volume to 79.07 of nitrogen. By weight, 23 parts of oxygen to 77 of nitrogen. In the air which we breathe are found small quantities of other substances such as watery vapor, carbon dioxide, ozone, ammonia, nitric and nitrous acids, hydrocarbons, solid

particles of dust, sodium chloride, vegetable germs or spores, bacteria, etc., etc. Air in which animals are confined contains some of the organic exhalations from their bodies; in the neighborhood of large cities the air is contaminated by various substances poured forth from manufacturing establishments. The air of cities contains more bacteria than that of the country. A cubic metre of Paris air was found to contain 3910 bacteria, as compared with 455 in a cubic metre of country air. Hospital air has been found to contain 40,000 to 79,000 microbes to the cubic metre.

120. **Carbon.**—In the form of charcoal, coke, and anthracite coal, carbon is used in the dental laboratory. In the form of animal charcoal and of wood charcoal it is used in dental medicine.

*Charcoal* is prepared on a large scale by burning wood in heaps with limited supply of air. *Carbo ligni* is the official preparation.

*Coke* is the substance left in retorts after coal has been distilled in the production of illuminating gas.

*Anthracite* coal is the result of slow decay of vegetable matter. It often contains 96 to 98 per cent. of carbon.

*Carbo animalis purificatus* consists of carbon and several salts of calcium notably the phosphate and the carbonate.

Charcoal and especially *animal* charcoal has the power of absorbing gases, of destroying noxious odors, and of filtering coloring matters from solutions of organic substances. One volume of wood charcoal at 212° F will absorb 90 volumes of ammonia gas, 55 volumes of sulphuretted hydrogen, and 9 volumes of oxygen. It is administered internally to counteract the effects of poisons, as for example strychnine, but should be removed by the stomach pump.

121. **Illuminating gas** is made by subjecting bituminous coal to the action of dry heat in retorts. The coal is heated to bright redness, and the products given off from it are passed through a series of upright tubes, in form of an inverted U, called *condensers* where the tar, steam, and ammonia are condensed. The gas is then passed through a series of large boxes called *purifiers*, in which it is purified by coming in contact with various substances as fresh slaked lime or a mixture of sawdust and iron oxide, and then it goes to a large tub-shaped vessel called the *gasometer* to be stored until needed.

It is a mixture essentially of hydrogen, and marsh-gas mixed with variable proportions of olefiant gas, acetylene,

the oxides of carbon, etc., etc. [Much of the illuminating gas now used is the so-called "water-gas," which contains usually a considerable amount of carbon monoxide, and is made by decomposing steam and then carburetting the gases formed].

122. **Sulphur.**—Flowers of sulphur is used in the manufacture of dental rubbers, as a vulcanizing material. Caoutchouc is heated till soft, then ground with 15 or 20 per cent. of sulphur and subjected to heat, pressure, and moisture.

123. **Phosphorus.**—Carious teeth, swollen and inflamed gums, finally necrosis of the jaws usually of the lower one, are often noticed in those who work in match factories. Most cases of phosphor-necrosis originate in unsound teeth or where the gums are kept away from the teeth by tartar.

About  $\frac{1}{70}$ th grain of phosphorus is contained in a match head. In the dipping and packing room the matches are handled the most, and in damp weather fumes are given off so that no workman with carious teeth should work in these rooms. Alkaline mouth-washes should be used and workmen should keep their hands clean and not eat in the work rooms. Good ventilation should be secured.

The use of *red* phosphorus instead of yellow is to be advised as the former is not poisonous.

124. **Chlorine.**—Chlorine gas has been used to bleach discolored teeth. It may be prepared as follows:

Place 20 parts, by weight, of commercial hydrochloric acid (sp. gr. about 1.16) in a flask, add 8 parts manganese dioxide, agitate, and after a time heat the flask on a sand bath (safety-tube may be used, which is a funnel-tube bent twice on itself). The equation is as follows:



The flask should be closed by a cork perforated by two holes, through one of which the safety-tube may be inserted, its lower end dipping below the surface of the acid; through the other hole a short glass tube bent at right angles should be inserted, its lower aperture being about an inch below the cork. The gas escapes through this second tube, called *delivery tube*, and may be collected in any way desired.

*Chlorine water* is used in dental practice as a local application. It is prepared by passing the gas into water in which it is readily soluble, one volume of water dissolving three volumes of chlorine gas. The solution *Aqua Chlori* U. S. P., is a greenish-yellow liquid, slowly changing in the light to

hydrochloric acid. It should not redden litmus, but bleach it. It should be kept in a glass-stoppered bottle away from the light and in a cool place. It should contain 0.4 per cent. of chlorine.

**Toxicology.**—Chlorine gas is an irritant poison, and is irrespirable causing inflammation of the air passages. The treatment is instant removal to fresh air, inhalation of ammonia or very dilute sulphuretted hydrogen or ether vapor. The inhalation of steam is said to be beneficial.

125. **Iodine.**—Tincture of iodine, *Tinctura Iodi*, is 80 grams of iodine in 920 grams of alcohol. Compound solution of iodine, *Liquor Iodi Compositus* is iodine 50 grams, potassium iodide 100 grams, distilled water 850 C. c. Decolorized tincture of iodine, *Tinctura Iodi Decolorata*, is iodine 40 grams, alcohol 400 C. c., stronger water of ammonia 90 C. c. Carbolyzed iodine solution, *Liquor Iodi Phenolatus* is tincture of iodine 1 gram, phenol (carbolic acid) 12 centigrams, glycerine 8 grams, water 45 C. c.; it is a colorless liquid.

The antidote for iodine is starch.

#### **General Properties of the Non-Metals.—**

[In Table 9 will be found a synopsis of the more important data with reference to the non-metallic elements: oxygen, hydrogen, nitrogen, carbon, sulphur, phosphorus, chlorine, bromine, iodine, fluorine, boron and silicon. It is deemed advisable to present information about them of theoretical and general value in the form of a table, rather than to take up space with a long description of each element. The reader will find the symbol, atomicity, atomic weight, molecular weight, density, specific gravity, weight of 1 litre of the gas or vapor, solubility in water, process if any by which the element may be liquefied, occurrence in nature, method of preparation, and the general properties of each element of non-metallic nature, described under the appropriate heading.

Under the head of the preparation of **oxygen** gas the process given is that of heating potassium chlorate; manganese dioxide is to be used in order that the gas may be evolved with greater regularity and freedom from explosion. The dioxide of manganese plays no part in the chemistry of the process, but may be recovered unchanged at the end. The reader is referred to the works of Wallian, and of Ehinger for details in regard to the processes by which oxygen gas may be prepared, and to the works on general chemistry for such information regarding gases as is not of special interest to the dentist.]



TABLE 9—NON-METALS AND THEIR PROPERTIES.

	Symbol.	Atoms in molecule	Atomic weight.	Molecular weight.	Density.	Specific gravity.	Weight of 1 litre gas (of vapor)	Solubility in water.	How liquefied.	Occurrence in nature.	Method of Preparation.	Properties.
<b>Oxygen.</b> Equivalence 2.	O	O <sub>2</sub>	16	32	16	1.10563	1.43	Water dissolves 3% in volume.	Pressure of 300 atmospheres and at -140° C.	Constitutes 20.93% by volume of atmosphere.	Heat potassium chlorate & MnO <sub>2</sub> . 2KClO <sub>3</sub> = 2KCl + 3O <sub>2</sub>	Has affinity for every element but fluorine. Colorless, odorless, tasteless, transparent gas. Supports combustion.
<b>Hydrogen.</b> Equivalence 1.	H	H <sub>2</sub>	1	2	1	0.0692	0.0896		650 atmospheres and at -140° C.	Exists in volcanic gases and in atmosphere of sun.	Decompose an acid by a metal: sulphuric acid by zinc. H <sub>2</sub> SO <sub>4</sub> + Zn = ZnSO <sub>4</sub> + H <sub>2</sub>	Affinity for chlorine only; at higher temperatures for oxygen. Colorless, tasteless, odorless, transparent gas. Combustible.
<b>Nitrogen.</b> Equivalence 5, 3, 1.	N	N <sub>2</sub>	14	28	14	0.971	1.256	1 part of water dissolves .025 part of nitrogen by volume.		Air containing 79.07% by volume of nitrogen	Obtained from air by burning phosphorus in a confined space.	Affinity for magnesium, boron, vanadium, titanium. Very inert chemically. Colorless, tasteless, odorless, transparent gas. Incombustible and does not support combustion.
<b>Carbon.</b> Equivalence 4, 2.	C		12			As diamond. 3.5		Insoluble		Diamond, graphite, coal, etc.	Animal charcoal obtained by heating bones to redness without access of air. Charcoal from wood heated to redness in limited supply of air.	Affinity for oxygen, hydrogen, sulphur. Insoluble, non-volatile, unalterable solid. Absorbs gases. Disinfectant.
<b>Sulphur.</b> Equivalence 6, 4, 2.	S	S <sub>2</sub> and S <sub>6</sub>	32	64	32	2.04	2.86 gr.	Insoluble in water. Best solvent carbon disulphide. Nearly insoluble in alcohol.	Melts at 114°C. (237°F.)	Occurs free in earth of volcanic regions of Sicily.	Distill crude brimstone in retort; vapor condensed into large chamber condenses in form of powder known as <i>flowers of sulphur</i> .	Affinity for many of the metals, for oxygen, carbon, etc. Forms many compounds. Lemon yellow solid, melting at 224°F. and boiling at 824°F. Brittle, tasteless, odorless. Does not conduct electricity nor heat.

Phosphorus. (Two varieties—Yellow and Red.)	P	P <sub>4</sub>	124	62	Of vapor	Yellow 1.83 Red 2.14		Yellow in water and alcohol; soluble in carbon disulphide. Red insoluble	Yellow melts at 111° F. under water.	Does not occur native, but as phosphates etc.	From ash of burnt bones by treating with sulphuric acid, and heating with charcoal.	Yellow is translucent, waxy shines in the dark, readily oxidized taking fire at 140° F. and must be kept under water. Becomes covered with red or white coat on exposure to light, poisonous. Red does not and is not poisonous. Phosphorus combines with most elements except C, N, and H, and reduces some metallic salts as of Cu, Ag.
Chlorine.	Cl	Cl <sub>2</sub>	35.4	71	35.4	2.47	3 17	1 part by volume of water dissolves nearly 3 volumes.	Pressure of 4 atmospheres or cold of -40° F.	Always in combination. Usual source common salt.	(a) Action of sulphuric acid on common salt in presence of mangane dioxide. (b) Action of air on moistened chloride of lime.	Greenish yellow, pungent, suffocating odor, wholly irrespirable, powerful bleaching agent and disinfectant. Combines with all elements except oxygen, nitrogen and carbon.
Bromine.	Br	Br <sub>2</sub>	80	160	80	3.187	7.15	33 parts water dissolve 1 of bromine.	At ordinary temperatures.	Gas combination as bromides, etc.	Action of sulphuric acid on bittern in presence of manganese dioxide.	Heavy dark brownish red liquid, less active than chlorine, bleaches, is poisonous, colors starch yellow.
Iodine.	I	I <sub>2</sub>	127	254	127	4.95	11.37	7000 parts of water dissolve 1 of iodine. Freely soluble in alcohol; and in aqueous solution potassium iodide.	At 255° F.	In combination, as iodides, etc.	From ashes of seaweeds. By action of chlorine and heat in liquor obtained by leaching seaweed ashes.	Brilliant scales of gray metallic color, giving off violet vapors. Yellowish brown stain to skin. Solutions when cold give blue color with boiled starch. Poisonous. Starch antidote.
Fluorine.	F	F <sub>2</sub>	19	38	19?		1.7?			Indecomposition in fluor-spar and cryolite.	Cannot be readily obtained.	Colorless gas.
Boron.	B	B <sub>2</sub>	11	22		2.68		Slightly soluble in water.	Oxygen flame.	In combination as borates, etc.	Action of sodium on potassium fluoborate.	Soft chocolate brown powder.
Silicon.	Si	Si <sub>2</sub>	28	56	28	2.49	2.5	Soluble in melted zinc, etc.	At temperature higher than melt iron.	In rocks as silicates or quartz, sand, etc.	Action of sodium on potassium fluo-silicate.	Occurs in three forms somewhat resembling carbon. Amorphous, nut brown powder.

## CHAPTER IV.

### COMPOUNDS OF THE NON-METALLIC ELEMENTS.

#### 126. Hydrogen monoxide or water.—

Synonyms: Aqua; distilled water, *Aqua Destillata*. Theoretical constitution:  $\text{H}_2\text{O}$ , hydrogen monoxide composed of two atoms of hydrogen and one of oxygen, by weight, 9 parts of oxygen to 1 of hydrogen. Molecular weight, 18. Specific gravity, 1.

Origin or manufacture: occurs in nature in lakes, rivers, etc., and in three states the solid as ice, the liquid, and the gaseous as steam or vapor. In the air it is in form of vapor. Seven-eighths of the human body is water. Is always formed when hydrogen or any substance containing hydrogen burns in the air. Thus,  $\text{CH}_4 + 2\text{O}_2 = \text{CO}_2 + \text{H}_2\text{O}$ .

The following are the most important *properties* of water: limpid colorless liquid, odorless, tasteless, neutral, poor conductor heat and electricity, 773 times heavier than air, standard of specific gravity, unites with positive oxides to form hydrates, with negative oxides or anhydrides to form acids. Enters into composition of many crystalline substances. Its solvent power is very much greater than that of any other liquid. The purest natural water is rain water. This, however, is somewhat contaminated with matters washed from the air. River and lake waters, especially those found in granitic regions, are the purest *potable* waters. *Mineral* waters are called alkaline, sulphurous, chalybeate, etc., according to prevailing constituents, and contain *usually* large amounts of solids in solution.

Use in dentistry: distilled water is used in the preparation of many dental formulæ. It is prepared by taking 80 pints of water, distilling two pints which are rejected, then distilling 64 pints. The term *aqua U. S. P.* is used as a name for a solution of some gaseous or volatile body in water, thus,

**aqua chlori**; the term **liquor** is used when the substance dissolved is fixed or solid as **Liquor Plumbi Subacetatis**.

**Toxicology:** in most States of the Union, water is not deemed poisonous.

### 127. **Hydrogen Dioxide.**—

**Synonyms:** hydrogen peroxide, hydric dioxide or peroxide, oxygenated water.

**Theoretical constitution:**  $\text{H}_2\text{O}_2$ , hydrogen dioxide, composed of two atoms of hydrogen and two of oxygen; by weight, 18 of oxygen to 1 of hydrogen. Molecular weight 34.

**Origin or manufacture:** pass a stream of carbon dioxide through water containing barium dioxide in suspension:



**Properties:** in the purest form it is a syrupy colorless liquid, having an odor like chlorine or ozone and a tingling metallic taste. It is never used in the purest undiluted form in dental operations owing to the facility with which it decomposes and gives off its oxygen. It is a powerful antiseptic, colorless, odorless, cleansing and stimulating, does not stain nor corrode, causes no pain, and is not poisonous. It gives off its oxygen with effervescence in contact with many substances and notably with pus. Application to dentistry: it effervesces with pus giving off nascent oxygen, which is a powerful bactericide; being one of the most cleansing of agents, it is used to clean cavities. Combined with weak alkali it bleaches. A "ten volume" solution of it is one which will give off ten parts by volume of oxygen; that is one measure of it gives off ten measures of oxygen. A ten volume solution contains 2.1 per cent. of the pure dioxide dissolved in water. A "two volume" solution contains 0.4 per cent. of the pure dioxide. A little acid is added to the solutions of the dioxide commonly used in dentistry, as it aids their stability; the amount is so small as to be of no great moment if the article is supplied by a reliable firm. Hydrogen dioxide should be kept in a cool place in a glass-stoppered bottle. *Glycozone* is hydrogen dioxide in solution in glycerine instead of water. It gives off its oxygen more slowly than an aqueous solution.

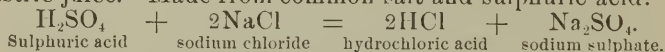
### 128. **Hydrogen Chloride or Hydrochloric Acid.**—

**Synonyms:** muriatic acid, chlorhydric acid, Acidum Hydrochloricum.

**Theoretical constitution:**  $\text{HCl}$ , a hydracid, binary com-

pound composed of one atom of hydrogen and one of chlorine; by weight 35.4 parts chlorine to 1 of hydrogen. Molecular weight 36.4. Density of the gas 18.25; sp. gr. 1.264. Absolute HCl contains 97.26 per cent. of chlorine and 2.74 per cent. of hydrogen.

Origin or manufacture: found free in small quantities in gastric juice. Made from common salt and sulphuric acid:



Properties: colorless transparent gas of pungent odor, strongly acid reaction, very soluble in water, one volume of which dissolves 450 volumes of the gas forming the ordinary **muriatic acid**. Commercial muriatic acid is yellow, and the strongest contains 25 to 30 per cent. of the gas. *Acidum muriaticum* or *Acidum Hydrochloricum* U. S. P. is colorless, sp. gr. 1.16, contains 31.9 per cent. of the gas. *Acidum Muriaticum Dilutum* U. S. P.: strong acid 6 parts, distilled water 13 parts; sp. gr. 1.049.

Use in dentistry: it is used as a solvent for zinc, and sometimes as a local application. It dissolves iron and zinc readily, and when warmed attacks tin.

Toxicology: hydrochloric acid is a corrosive poison, caustic and escharotic. It stains the skin at first white, then produces discoloration. The stain on black cloth is red, gradually disappearing in course of time. Burns by the acid should be treated first by washing the acid off well, then by application of sodium bicarbonate solution and oil. If the acid be taken internally give at once magnesia or bicarbonate of sodium in milk at short intervals, then bland liquids as raw eggs, gruel or oil.

#### 129. **Hydrogen Sulphide or Sulphuretted Hydrogen.**—

Synonyms: hydric sulphide, sulphydric acid, hydrosulphuric acid, *Acidum Hydrosulphuricum*.

Theoretical constitution:  $\text{H}_2\text{S}$ , two atoms of hydrogen to one of sulphur; by weight, 16 parts of sulphur to 1 of hydrogen; molecular weight, 34; density, 17.2; sp. gr., 1.192. Weight of a litre, 1.540 grammes.

Origin or manufacture: it is found in volcanic gases, in some mineral springs, and as a result of the decomposition of organic matter containing sulphur, as in the intestines and the teeth. It is usually made by the action of a dilute acid on a sulphide as for example:



Properties: colorless, fetid gas, combustible, soluble in water, readily recognized by its odor (that of rotten eggs), valuable as a re-agent, yields precipitates with salts of many metals. Blackens unsized paper saturated with solution of sugar of lead. Poisonous.

Application to dentistry: its odor, if recognized in the breath, indicates that decomposition is going on somewhere in the mouth.

Its action on the various metals and compounds used in dentistry is of the utmost importance. It forms *sulphides* with silver, mercury, lead, copper, bismuth; these sulphides are all dark in color, and the *blackening* observed in amalgam fillings is due to formation of these compounds. It also forms sulphides with arsenic, antimony, cadmium, and tin, but these sulphides are not black; the sulphide of arsenic is yellow, that of antimony orange, cadmium yellow, tin yellow or brown. Sulphuretted hydrogen does not act on *metallic* gold, platinum, palladium, iridium, nor does it blacken iron, cobalt, nickel, manganese, zinc, chromium nor aluminium.

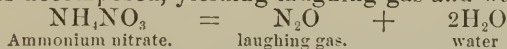
### 130. Nitrogen Monoxide or Laughing Gas.—

Synonyms: hyponitrous oxide, nitrous oxide, nitrogen protoxide.

Discovered by Priestly in 1776; first came into notice as an anæsthetic in 1863; first used in dentistry by Wells of Hartford, in 1845.

Theoretical constitution:— $\text{N}_2\text{O}$ , hyponitrous oxide or nitrogen monoxide; univalent nitrogen with bivalent oxygen—two atoms of nitrogen with one of oxygen; composition by volume, 2 parts of nitrogen to 1 of oxygen, by weight 28 parts of nitrogen to 16 of oxygen. Molecular weight, 44. Density, 22. Sp. gr. 1.527. Weight of a litre 1.98 gramme.

Preparation: made by cautiously heating ammonium nitrate which is decomposed, yielding laughing gas and water:



Properties: colorless, odorless, sweetish-tasting gas of neutral reaction, soluble in water, 100 volumes of which dissolve 78 volumes of the gas, more so in alcohol. Supports combustion, the heat of burning bodies decomposing it and setting oxygen free. Condenses to a colorless liquid under pressure of 50 atmospheres and temperature of 45°F. Specific gravity of the liquid, 0.908. Boiling point —126°F., freezing point —150°F.

When inhaled it causes exhilaration, anæsthesia, and finally



asphyxia. It dissolves in the blood without entering into combination with it and its action seems to be due partly to its excluding air and partly to its direct effect on the nervous system. The anæsthesia produced by it is of short duration and without an excitement stage. The sensation is usually one of agreeable intoxication and disagreeable after-effects are wanting. Lyman holds that the anæsthesia is a narcosis, but Wallian thinks with Ziegler that it is not merely an asphyxiating agent.

Use in dentistry: as a temporary anæsthetic. Out of 121, 709 administrations of the gas recorded from 1863 to 1881 there was not one which resulted fatally, nor produced serious ill-effects.

For anæsthetic purposes the nitrogen monoxide is liquefied and sold in wrought-iron cylinders provided with a stop-cock on turning which the liquid is vaporized and may be collected in rubber gas bags or small gasometers. When the gas is to be administered it may be inhaled from the gas bag or gasometer through a rubber tube and mouth-piece provided for the purpose. The advantages of the cylinder are that the gas may be kept for any length of time without loss of strength or volume.

### 131. Carbon Disulphide.—

Synonyms: carbon bisulphide, carbon bisulphuret or bisulphuret of carbon. Official name, Carbonei Bisulphidum.

Theoretical constitution:  $\text{CS}_2$ , one atom of carbon and two of sulphur. Molecular weight, 76.

Preparation: made by passing fumes of sulphur over red hot charcoal.

Properties: mobile colorless liquid of disgusting odor except when pure. Very volatile. Dissolves iodine, sulphur, phosphorus, oils, fats, caoutchouc, etc. Sometimes used as local anæsthetic.

Use in dentistry: to dissolve caoutchouc.

### 132. Hydrogen Nitrate or Nitric Acid.—

Synonyms: hydric nitrate, Glauber's spirits of nitre, spirits of nitre, fuming spirits of nitre, aqua fortis, azotic acid. Official name, Acidum Nitricum.

Known to the Arabs in the 9th century.

Theoretical constitution:  $\text{HNO}_3$ , an ox-acid whose molecule is composed of 1 atom of hydrogen, 1 of nitrogen, and 3 of oxygen. By volume it consists of 1 part of hydrogen, 1 of nitrogen, and 3 of oxygen. By weight, 1 part of hydrogen, 14 of nitrogen, 48 of oxygen. Molecular weight, 63.



Preparation: made by decomposing potassium nitrate (nitre) with sulphuric acid:



Properties: the pure acid is a colorless, fuming, corrosive, rather heavy, strongly acid liquid of sp. gr. 1.52. The official acid has a specific gravity of 1.42 and contains 69.4 per cent. of absolute acid to 30.60 per cent. of water. Exposed to air and light it is decomposed and becomes yellow. Nitric acid dissolves mercury, copper, silver, and bismuth especially when warmed; *dilute* nitric acid dissolves iron, lead and silver. Antimony and tin are attacked by the acid and oxidized but not dissolved. Nitric acid has no action on gold, platinum, nor iridium. It attacks and destroys vegetable and animal tissues, producing a yellow discoloration, especially on animal matters and products. Its salts are *nitrates*.

*Acidum Nitricum, Dilutum* is one part of the official acid to six of distilled water. Its sp. gr. is 1.059 and it contains 10 per cent. of  $\text{HNO}_3$ . Specific volume, 0.944.

Use in dentistry: mixed with four parts of hydrochloric acid, it is used to dissolve gold. [The official mixture is 4 parts nitric acid by weight, to 15 of hydrochloric acid, and is called *Acidum Nitrohydrochloricum*.]

Nitric acid is also used to dissolve zinc in the preparation of the oxphosphate cement. It is used in dental medicine as a caustic. It attacks the teeth and hence when used in any form in the mouth care should be taken that it does not touch other tissues than the ones to which it is applied.

Toxicology: nitric acid is a violent poison turning the mucous membranes a bright yellow and then corroding them. The *antidotes* are alkalies or magnesia suspended in water, sodium bicarbonate in water, soap and water; bland liquids should be given and the patient's strength sustained.

### 133. Hydrogen Sulphate or Sulphuric Acid.—

Synonyms: hydric sulphate, oil of vitriol, dihydric sulphate, vitriol, spirit or essence of vitriol.

Theoretical constitution:  $\text{H}_2\text{SO}_4$ , hydrogen sulphate, an ox-acid composed of two atoms of hydrogen, one of sulphur, and four of oxygen; by weight 2 parts hydrogen, 32 of sulphur, 64 of oxygen. Molecular weight 98. Its salts are *sulphates* as for example zinc and sulphuric acid form zinc sulphate.

Preparation: the crude acid is prepared by the action of nitric acid on sulphurous oxide, producing sulphuric oxide

which uniting with water forms sulphuric acid. The sulphurous oxide may be made by burning sulphur in air. The acid is concentrated by evaporation until a sp. gr. of 1.84 is obtained, when it contains about 96 per cent. of pure sulphuric acid.

Properties: colorless, odorless, heavy, oily liquid. Generates heat on addition of water. Very caustic. Stains fabrics reddish, and chars organic matter. Stain removed by ammonia. Valuable for drying gases on account of its affinity for moisture. Sp. gr. pure 1.848; officinal 1.843.

The charring of organic matter by sulphuric acid is due to the fact that it unites with the hydrogen and oxygen in them leaving behind compounds so carbonaceous that the black color predominates. It corrodes animal tissues. Starch or cellulose boiled with dilute sulphuric acid is converted into glucose; cane sugar into levulose and glucose. Sulphuric acid dissolves most of the metals, but has little action on lead.

*Acidum sulphuricum* U. S. P. called the C. P. acid, sp. gr. 1.84. Contains at least 96 per cent. of  $\text{H}_2\text{SO}_4$ .

*Acidum sulphuricum dilutum*, U. S. P. sp. gr. 1.067; 1 part of sulphuric acid by weight to 9 parts of distilled water.

*Acidum sulphuricum aromaticum* about same strength as *dilutum*; contains alcohol, cinnamon oil and tincture of ginger.

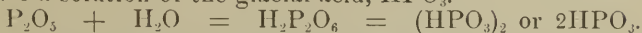
Application to dentistry: in the dental laboratory the acid is used for cleaning metallic plates previous to soldering and after soldering. Its action is more vigorous when it is diluted with water, say with about one-third of water, heat being generated. Its action on hemppaper is to reduce it to pyroxylin hence it is used in the preparation of celluloid base.

In dental therapeutics, in dilute form, it is used as a local application in various affections of the mouth. It is caustic, and will dissolve thin carious portions of bone.

Toxicology: the concentrated acid (or the dilute in large doses) is a corrosive poison. Its stain on cloth is usually a dirty brown or reddish brown, and the cloth becomes rotten and damp. It chars wood. Vomited matters will contain a brownish colored bloody liquid with free acid. The treatment is to give lime, magnesia, sodium carbonate, preferably in milk. Burns from the acid should be treated like those of nitric acid.

134. **Anhydrous Phosphoric Acid** so called is phosphoric anhydride, *i. e.* phosphoric oxide or phosphorus pentoxide,  $\text{P}_2\text{O}_5$ , and is formed by the rapid burning of phosphorus in

air or in oxygen. It is very deliquescent. It forms with water a solution of the glacial acid,  $\text{HPO}_3$ .



135. **Hydrogen Phosphate or Phosphoric Acid.**—

There are several kinds of phosphoric acid, but we shall here speak of two only.

1. **Common Phosphoric Acid.**—

Synonyms: tri-basic phosphoric acid, tri-hydrogen phosphate; (it is sometimes called ortho-phosphoric acid.)

Theoretical constitution:  $\text{H}_3\text{PO}_4$ ; may be regarded as mono-meta-phosphoric acid, *i. e.*, the acid obtained by removing one molecule of water from true ortho-phosphoric acid. Ortho-phosphoric acid has for its formula  $\text{H}_5\text{PO}_5$  which formula minus  $\text{H}_2\text{O}$  becomes  $\text{H}_3\text{PO}_4$  graphically  $(\text{PO})'''(\text{HO})_3$ . The acid contains, then, three atoms of hydrogen, one of phosphorus, and four of oxygen; by weight 3 parts hydrogen, 31 of phosphorus, 64 of oxygen. Molecular weight 98. Its salts are phosphates.

Origin or preparation: made by boiling phosphorus in dilute nitric acid and evaporating to a syrupy liquid.

Properties: syrupy liquid which if evaporated spontaneously over sulphuric acid gives hard, transparent, prismatic crystals readily deliquescent. It does not coagulate albumin.

**Acidum Phosphoricum**, U. S. P. is a colorless, strongly acid liquid of sp. gr. 1.347. It does not fume and should not contain arsenic. It contains 50 per cent. acid to 50 of water. It is odorless.

**Acidum Phosphoricum Dilutum**, U. S. P., contains 10 per cent. of  $\text{H}_3\text{PO}_4$ , and is composed of 1 part of Acidum Phosphoricum in 4 of distilled water.

2. **Glacial Phosphoric Acid.**

Synonyms: mono-hydrogen phosphate, meta-phosphoric acid, di-meta-phosphoric acid, mono-hydrated phosphoric acid.

Theoretical constitution:  $\text{HPO}_3$  or di-meta-phosphoric acid *i. e.*, derived by subtracting two molecules of water from true ortho-phosphoric acid.  $\text{H}_5\text{PO}_5 - 2\text{H}_2\text{O} = \text{HPO}_3$ . Its molecule therefore consists of 1 part hydrogen, 1 part phosphorus, and 3 parts oxygen; by weight 1 part hydrogen, 31 of phosphorus, and 48 of oxygen. Molecular weight 80.

Origin or preparation: it may be made by heating the ordinary acid, which loses a molecule of water and becomes the glacial acid.



It is usually made by calcining ammonium phosphate, but the product is likely to contain ammonia.

Properties: on cooling the platinum vessel in which common acid,  $\text{H}_3\text{PO}_4$ , has been heated to redness a vitreous mass,  $\text{HPO}_3$ , is seen, hard, colorless, transparent, not crystallizable, readily soluble in water, forming an intensely acid solution which is slowly converted into the ordinary acid. It coagulates albumin. In commerce it comes in the form of sticks or brittle cakes, odorless, sour to the taste, and hygroscopic, more or less contaminated with pyro-phosphoric acid, and containing phosphates of sodium, calcium, magnesium, etc. Solution of the common acid in water when heated becomes first pyro-phosphoric acid, then (at red heat) glacial phosphoric acid.

Use in dentistry: the dilute acid is used as a local application in caries and has been given internally. It is liable to fungoid growth of a tenacious or mucoid character, diffusible, and of a yellowish-gray color; it loses strength on development of this growth, its specific gravity falling below 1055 often.

*Syrupy phosphoric acid:*  $\text{H}_3\text{PO}_4$ , syrupy phosphoric acid contains on an average, about 66 per cent. of  $\text{H}_3\text{PO}_4$  and as sold by manufacturing chemists is not the glacial acid but merely a strong phosphoric acid of syrupy consistence. It is of different strengths according to the makers.

TABLE 10—PHOSPHORIC ACIDS.

COMMON PHOSPHORIC ACID.	GLACIAL PHOSPHORIC ACID.
$\text{H}_3\text{PO}_4$ . Called by some ortho-phosphoric acid. Syrupy liquid.	$\text{HPO}_3$ . Called meta-phosphoric acid. Solid.
Evaporated spontaneously yields prismatic crystals.	Does not crystallize, but forms an amorphous, glassy, mass.
Does not coagulate albumin.	Coagulates albumin.
Strong acid is called syrupy phosphoric acid.	Slowly turns into the common acid.
The official acid (50 per cent) heated above $392^\circ\text{F}$ . is converted gradually into the glacial acid and pyrophosphoric acid.	Is volatile at red heat and when boiled with water is converted into the common acid.
Little or no precipitate with solution of silver nitrate.	Abundant precipitate with solutions of silver nitrate.

*Cements.*—The phosphoric acid used in making oxyphosphate cement is, in those which I have examined, the *glacial* acid. It should be remembered that the glacial acid is slowly

converted into the common acid and also when boiled with water.

### 136. Hydrogen Orthoborate or Boracic Acid.—

Synonyms: boric acid, orthoboric acid, sedative salt of Homberg. Official name, Acidum Boricum.

Theoretical constitution: orthoboric acid  $H_3BO_3$ , graphically  $B'''(HO)_3$ . Composed of three atoms of hydrogen, one of boron, and three of oxygen. By weight, 3 parts of hydrogen, 11 of boron, and 48 of oxygen. Molecular weight, 62.

Preparation: boracic acid is made from borax by adding hydrochloric acid to a hot solution of the former, which causes a precipitate of boracic acid:



Properties: brilliant, white, shining, inodorless, six-sided plates, greasy to the touch, slightly soluble in cold water, 1 part in 25, soluble in 3 parts hot water, soluble in 6 parts alcohol, soluble in glycerine. Specific gravity, 1.517 at ordinary temperature. Is a powerful antiseptic. Saturated with alcohol, burns with a green flame. Its solutions are but faintly acid; turmeric paper moistened with a solution of this acid becomes reddish-brown on drying. Boiled with glycerine forms *boroglyceride*. (See Boroglyceride under head of Glycerine).

Use in dentistry: boracic acid is used for various antiseptic purposes. Combined with sodium sulphite it is used as a bleaching agent for discolored teeth. (See Boroglyceride).

**Other Compounds of the Non-Metals:**—The compounds already considered include those of special importance to the dentist. In the course of the work, however, certain other compounds will be mentioned, especially *ammonia*, *carbon dioxide*, *silica*, and *sulphurous acid*, the chief properties, etc., of which are presented to the reader in the following Table.

**Ammonia** gas is especially of interest on account of being a product of the putrefaction of animal matters. (See Proteids and Putrefaction.)

**Carbonic Acid gas**, known to chemists as carbonic dioxide, or carbon dioxide, is a constituent of the breath, is found in small quantities in the atmosphere, and is a product of fermentation. It is not a true acid, as defined in this book, but an *anhydride*, carbonic anhydride,  $CO_2$ . The hydrated acid is not found, but its salts exist, as, for example, the various *carbonates*, like sodium carbonate,  $Na_2CO_3$ .

TABLE 11.—VARIOUS COMPOUNDS OF INTEREST.

Popular Name.	Chemical Formula.	Preparation.	Properties.
Ammonia Gas.	$H_3N$ Molecular weight, 17; density, 8.5; sp. gr., 0.59.	Product of putrefac- tion of animal mat- ter. Made by heat- ing sal-ammoniac and quicklime.	Colorless gas, pungent odor, strongly alkaline, sp. gr. 0.59, extraordi- narily soluble in water, 1149 volumes of the gas in 1 of water. Very vo- latile.
Carbonic Oxide Gas.	$CO$ Molecular weight, 28; density, 14; sp. gr., 0.9678. Carbon mon- oxide.	Formed when carbon is burned in deficient supply of air. Is a constituent of "water gas."	Colorless, insipid, very poisonous, insoluble, combustible.
Carbonic Acid Gas.	$CO_2$ Molecular weight, 44; density, 22; sp. gr., 1.529.	Product of combus- tions and fermenta- tion. Made by pour- ing an acid on a car- bonate, as sulphuric acid on marble or limestone.	Colorless, odorless, pres- ent in air, water, breath, heavier than air. Nar- cotic. Slightly acid taste. Very soluble in water. Compounds are <i>carbon- ates</i> .
Silica.	$SiO_2$	Occurs in nature as quartz crystal and in sand. Is found in animal tissues. Com- pounds are <i>silicates</i> .	Insoluble in water or acids, infusible except by oxyhydrogen flame, sp. gr., 2.66. Percentage composition, silicon, 48.04, oxygen, 51.96. Used in manufacture of porcelain teeth.
Sulphurous Acid.	$H_2SO_3$	Made by dissolving sulphurous anhy- dride $SO_2$ in water. The latter is made by burning sulphur.	Unstable liquid of suffo- cating odor. Used for bleaching purposes. Compounds are <i>sulph- ites</i> .



## CHAPTER V:

COMPOUNDS OF SODIUM, POTASSIUM, AMMONIUM, CALCIUM,  
MAGNESIUM, ARSENIC, AND CHROMIUM.

137. It is deemed advisable to study the metals in two chapters; chapter V will be devoted to the consideration of those metals whose *compounds* alone are of interest to the dentist, as sodium, potassium, etc. In chapter VI the subject of Metallurgy will be taken up, and those metals discussed which are of interest, not only through their compounds, but also on account of themselves, their alloys, and amalgams.

138. **Sodium Compounds.**—

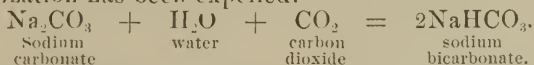
139. **Sodium Hydro-Carbonate or Bicarbonate.**—

Synonyms: bicarbonate of sodium, bicarbonate of soda, sodium acid carbonate, sesquicarbonate of sodium, “baking soda.”

Theoretical constitution: sodium hydrocarbonate,  $\text{NaHCO}_3$ , is what is called an **acid salt**, because *all* the hydrogen atoms of the acid from which it is derived have *not* been replaced by the positive atom. The term **acid salt** should not confuse the beginner as to the *reaction* of the substance, which has nothing to do with the theoretical name.

Sodium bicarbonate is composed of one atom of sodium, one of hydrogen, one of carbon, and three of oxygen. By weight 23 of sodium, 1 of hydrogen, 12 of carbon, 48 of oxygen, molecular weight 84.

Preparation: made by passing carbon dioxide over sodium carbonate, from which the larger portion of water of crystallization has been expelled:



The *sodium carbonate* used is, as will thus readily be seen, an entirely different substance from the bicarbonate. The



former is known in commerce as "sal soda," familiarly known as "washing soda."

Properties: sodium bicarbonate is a white powder, having a mildly saline cooling taste, a slightly alkaline reaction, soluble in 12 parts of water, insoluble in alcohol; 8 parts of the bicarbonate are soluble in 100 of glycerine (by weight). Its solutions are nearly neutral to litmus paper.

Use in dentistry: sodium bicarbonate is in particular used as an antacid ingredient of dentifrices, and its uses in general in dental practice are in consequence of its antacid properties.

140. Various sodium compounds: all are soluble in water to a greater or less degree and most of them in solution turn red litmus blue. Many of them are white or colorless.

TABLE 12—SODIUM COMPOUNDS.

Name.	Formula.	Origin, Uses, etc.
Chloride	NaCl	{ Common salt; is found in every fluid and organ of the body.
Sulphite	Na <sub>2</sub> SO <sub>3</sub>	{ Antiseptic, disinfectant, and deodorizer. Used in bleaching teeth with boracic acid.
Sulphate	Na <sub>2</sub> SO <sub>4</sub>	Glauber's salt.
Carbonate	Na <sub>2</sub> CO <sub>3</sub> , 10H <sub>2</sub> O	Washing Soda.
Arseniate	Na <sub>2</sub> HAsO <sub>4</sub> , 7H <sub>2</sub> O	Poisonous, colorless, efflorescent.
Hydrate	KHO	{ Caustic soda. Comes in form of sticks. Readily soluble.
Phosphates	<div> <div>{</div> <div>Na<sub>3</sub>PO<sub>4</sub></div> <div>Na<sub>2</sub>HPO<sub>4</sub></div> <div>NaH<sub>2</sub>PO<sub>4</sub></div> </div>	<div> <div>{</div> <div>Basic phosphate, alkaline and purgative.</div> <div>Neutral phosphate. Found in the tissues.</div> <div>Acid phosphate of sodium.</div> </div>

#### 141. Sodium Borate or Borax.—

Synonyms: sodium biborate, sodium tetraborate, Sodii Boras (U.S.P), Sodæ Boras (B.P).

Theoretical constitution: formula Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub>, explained by regarding it as Na<sub>2</sub>O.(B<sub>2</sub>O<sub>3</sub>)<sub>2</sub> or Na<sub>2</sub>O.2B<sub>2</sub>O<sub>3</sub>. Boric oxide (anhydride) B<sub>2</sub>O<sub>3</sub>, has the property of uniting directly with oxides of the positive elements sodium, potassium, etc. Borax

is not therefore derived from boracic acid but by the direct combination of sodium oxide,  $\text{Na}_2\text{O}$ , with boric oxide or anhydride,  $\text{B}_2\text{O}_3$ . The molecule of sodium oxide requires *two* molecules of the boric oxide, forming  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3$ . Borax contains also ten molecules of water of crystallization, so that the full formula is  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 + 10\text{H}_2\text{O}$ .

Properties and uses in dentistry: borax is a white, soluble, efflorescent substance which melts at a low heat, swells greatly, at a higher temperature becomes a clear liquid, then a vitreous substance (borax glass). It is useful in blow pipe analysis, as by the "borax bead" method; as a flux for melting metals; in soldering metals; in solution, for hardening plaster casts; as a local application, etc., etc.

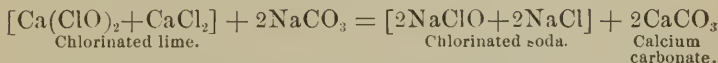
#### 142. Sodium Hypochlorite.—

Theoretical constitution:  $\text{NaClO}$ , one atom of sodium, one of chlorine and one of oxygen in its molecule. This substance is only indirectly of interest as one of the ingredients of the chlorinated soda solution.

##### *Liquor Sodae Chloratae.*

Synonyms: Labarraque's solution, solution of chloride of soda; chlorinated soda solution.

Preparation: made by decomposing a solution of chlorinated lime with one of sodium carbonate:



Properties: clear, pale liquid, slightly greenish yellow in color, of faint chlorine odor, alkaline taste and reaction. Sp. gr. 1.044. Powerful disinfectant, deodorizer, antiseptic, bleaching agent.

Use in dentistry: used locally for its antiseptic etc., properties and as a bleaching agent for discolored teeth, in combination with powdered alum. It slowly decomposes on exposure to air and light, and should be kept in a dark place in a bottle provided with a glass stopper. It is advisable to keep soda solutions in bottles whose glass stoppers have been dipped in paraffine.

Eau de Javelle contains potassium hypochlorite.

## 143. Potassium Compounds.—

TABLE 13—SOME COMPOUNDS OF POTASSIUM.

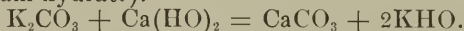
Name.	Formula.	Uses, etc.
Chlorate	$\text{KClO}_3$	White, soluble in water (6 in 100). Used in mouth washes and gargles. In large doses is poisonous. Sparingly soluble in alcohol.
Bicarbonate	$\text{KHCO}_3$	Antacid, used in mouth washes. In large doses is corrosive poison. Soluble in water, insoluble in alcohol.
Bromide	$\text{KBr}$	White, soluble, crystals. Given internally in convulsions, etc., and used locally to diminish sensibility before taking impressions.
Chloride	$\text{KCl}$	Transparent, colorless solid, soluble in water. Found in the body in fluids, blood corpuscles, and in muscle juice.
Iodide	$\text{KI}$	Made by dissolving iodine in potassium hydrate. Large, white, translucent, cubical crystals of a saline taste. Readily soluble in water. Solutions dissolve iodine.

## 144. Potassium Hydrate —

Synonyms: Potassa U.S.P., Potassa Caustica (Br.P.), caustic potash.

Theoretical constitution:  $\text{KHO}$  or  $\text{KOH}$ , the hydrate (hydroxide) of potassium. Molecular weight, 56.

Preparation: by boiling potassium carbonate with slacked lime (calcium hydrate).



Properties: the impure contains lime and is called potash by lime; purified by dissolving in alcohol and evaporating to dryness, remelted and cast in sticks it is known as potash by alcohol. White opaque sticks or lumps, alkaline, readily soluble in water, caustic, escharotic, and corrosive poison.

*Potassa cum calce*: equal parts  $\text{KHO}$  and  $\text{CaO}$ , grayish white powder, milder and less deliquescent; in a paste called *Vienna paste*, used in dentistry.

*Robinson's remedy* contains potassium hydrate and carbolic acid, equal parts.

Liquor potassæ is a 5 per cent. solution of potassium hydrate in water.

**Toxicology:** potassium hydrate is a corrosive poison and its action on tissues is very violent and penetrating. Forty grains have caused death. In the treatment the stomach pump must *not* be used, dilute vinegar should at once be given, lemon juice, orange juice, olive oil, and milk freely. Stimulants are indicated if there is much pain. Solutions of potassium hydrate or carbonate have a soapy feel and are alkaline in reaction. Burns from the agent should be treated with dilute vinegar and then with oil.

**145. Potassium Nitrate.—**

Synonyms: nitre, saltpetre, Sal Prunella. Official name, Potassii Nitras.

Theoretical constitution:  $\text{KNO}_3$ , 1 atom of potassium, 1 of nitrogen and 3 of oxygen to the molecule. Molecular weight, 101.

Preparation: made from crude sodium nitrate by double decomposition with potassium chloride.

Properties: colorless crystals, anhydrous, very soluble in hot water, readily soluble in cold, nearly insoluble in alcohol, permanent in dry air, neutral, odorless.

Uses in dentistry: locally and in mouth washes as an antiseptic and refrigerant. In refining gold, when it is used as an oxidizing agent for metals alloyed with gold. Roasting an alloy with nitre will often set the gold free.

**Toxicology:** potassium nitrate is poisonous, causing severe burning abdominal pains, nausea, vomiting of blood, great prostration, tremors, collapse. One ounce has proved fatal. The treatment is to give an emetic, mucilaginous and demulcent drinks, and stimulants.

**146. Potassium Permanganate.—**

Synonyms: permanganate of potash. Official name, Potassii Permanganas.

Theoretical constitution:  $\text{K}_2\text{Mn}_2\text{O}_8$  or  $\text{KMnO}_4$ , derived from permanganic acid. Permanganic acid,  $\text{H}_2\text{Mn}_2\text{O}_8$ , may be deemed to be derived from manganese heptoxide ( $\text{Mn}_2\text{O}_7$ ) plus water ( $\text{H}_2\text{O}$ ); potassium permanganate,  $\text{K}_2\text{Mn}_2\text{O}_8$ , by exchanging the two atoms of hydrogen in the acid for two of potassium. Molecular weight, 313.8.

Properties and dental uses: potassium permanganate occurs in the form of dark purple crystals which impart a fine deep purple color to water even when in very minute proportion. It is a deodorizer and disinfectant and in concentrated solution a caustic.

*Condy's Fluid* contains 32 grains of it to the pint of distilled water.

*Liquor Potassii Permanganatis* contains 64 grains to the pint of distilled water.

In dental practice the permanganate is used locally as a deodorizer, disinfectant and antiseptic.

#### 147. Ammonium and its Compounds.—

Ammonium ( $\text{NH}_4$ ) is what is known as a *radical* (see Organic Chemistry). It is not positively known to exist nor is its oxide. There are reasonable grounds, however, for supposing that it does actually exist in certain compounds called the ammonium compounds, all of which contain  $\text{NH}_4$  in their formulæ. Ammonium is not ammonia; the latter is a well-known gas,  $\text{NH}_3$ , while ammonium has never been isolated and has therefore only a hypothetical existence. Ammonium would seem in the main to resemble sodium and potassium; there are, however, points of dissimilarity.

TABLE 14—COMPOUNDS OF AMMONIUM.

Names.	Formula.	Properties.
<b>Hydrate,</b> (Ammonia water)	$\text{H}_4\text{NHO}$ or $\text{NH}_4\text{HO}$ Sometimes written $\text{AmHO}$ . May be deemed a hydrate of the radicle ammonium.	Volatile, caustic liquid of powerful odor. Aqua Ammoniac is a solution of ammonia gas in water, of sp. gr. 0.959. Aqua Ammoniac Fortior contains 28 per cent. of the gas and is of sp. gr. 0.900; it is a powerfully corrosive poison.
<b>Carbonate,</b> Ammonii carbonas. Hartshorn salt. Sal Volatile.	$(\text{NH}_4\text{HCO}_3, \text{NH}_4\text{NH}_2\text{CO}_2)$ Really a mixture of the acid carbonate and the carbamate. Molecular wt., 157.	Has strong odor of ammonia and is freely soluble in water. Loses $\text{CO}_2$ and $\text{NH}_3$ on exposure to the air.
<b>Chloride,</b> or muriate. Sal ammoniac.	$\text{NH}_4\text{Cl} =$ 53.4	White crystalline powder; very easily soluble in water, but not hygroscopic. Used as flux in refining gold, etc., and locally.

#### 148. Calcium Compounds. Calcium Sulphate.—

Synonyms: sulphate of calcium, sulphate of lime, plaster-of-Paris, calcic sulphate. Official name, Calcii Sulphas.

Theoretical constitution:  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ , one atom of calcium, one of sulphur and four of oxygen; by weight 40 parts calcium, 32 parts sulphur, 64 parts oxygen. Molecular weight, 172.

Preparation: calcium sulphate occurs in nature as a mineral called gypsum. Gypsum, however, differs from the dried calcium sulphate of commerce in that it contains two molecules of water of crystallization; the full formula for gypsum is,

therefore,  $\text{CaSO}_4, 2\text{H}_2\text{O}$ . Ground gypsum is called *terra alba*. Gypsum when heated to  $392^\circ\text{F}$ . loses its water of crystallization becoming changed into a white, opaque mass having  $\text{CaSO}_4$ , without any  $\text{H}_2\text{O}$ , for its formula. This substance when ground is known as plaster-of-Paris and is anhydrous calcium sulphate; it readily recombines with water becoming a hard mass on the addition of  $\text{H}_2\text{O}$ .

Properties and uses: the anhydrous sulphate,  $\text{CaSO}_4$ , plaster-of-Paris, is a hard, white, nearly insoluble substance. After taking up water it "sets" into a stone-like solid, and hence is useful in making moulds, casts and immovable surgical dressings. If alum and gelatine be mixed with the plaster-of-Paris before addition of water it forms a harder and less porous mass than the plaster alone, and presents a smooth surface which can be washed with water containing the various disinfecting agents.

#### 149. Calcium Carbonate.—

Synonyms: calcic carbonate, Calcis Carbonas, carbonate of lime. Official name, Calcii Carbonas Præcipitatus.

Theoretical constitution:  $\text{CaCO}_3$ , one atom of calcium, one of carbon, three of oxygen; by weight 40 parts calcium, 12 carbon, 48 oxygen. Molecular weight, 100.

Origin and method of preparation: it occurs more or less pure in nature as chalk, limestone, marble, Iceland spar, coral, shells, etc. It is found in the bones, teeth, saliva, and in calculi, and tartar.

It is obtained for dental uses (1) by precipitation, by mixing solutions of calcium chloride and sodium carbonate:



(2) as prepared chalk (*Creta Præparata*) by grinding a native chalk in water, allowing the mixture to settle, decanting the upper portion, collecting and drying the finer particles.

Properties and uses: precipitated calcium carbonate is a neutral, white, tasteless, impalpable powder; it is insoluble in pure water and in alcohol, but soluble in water containing carbonic dioxide (carbonic acid). It is found as acid carbonate, dissolved in almost all natural waters, causing *hardness*, which may be removed by boiling, hence called "temporary" hardness.

It is used in dentistry as a polishing powder, as an ingredient of dentifrices, and as an antacid. It is useful as an antidote in cases of poisoning by acids.

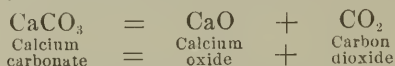


### 150. Calcium Oxide.—

Synonyms: calcic oxide, lime, Calx, quicklime, burned lime. Official name, Calcii Oxidum.

Theoretical constitution:  $\text{CaO}$ , calcium oxide, one atom of calcium and one of oxygen in its molecule; by weight 40 parts of calcium to 16 of oxygen. Molecular weight, 56.

Preparation: lime is obtained on a large scale by heating limestone or other calcium carbonate in a lime kiln.



For pharmaceutical purposes, marble is heated in a Hessian crucible.

Properties and uses: lime is a grayish-white amorphous solid, odorless, infusible, of alkaline taste and reaction. It becomes incandescent in the oxy-hydrogen flame, emitting a very intense white light. Made from marble it should be pure white.

151. **Calcium Hydrate.**—Slaked lime, Calcii Hydras. Formula,  $\text{Ca}(\text{HO})_2$ . Molecular weight, 74. Prepared by adding 10 parts water to 16 of lime, letting cool, and straining. Dry, white, odorless, tasteless, alkaline powder. Only recently prepared calcium hydrate should be used, as it soon becomes carbonate, absorbing carbonic dioxide from the air.

**Mortar** is a mixture of sand, water and slaked lime; it hardens as the water evaporates, as part of the lime becomes a carbonate on absorbing carbon dioxide from the air, and especially when part becomes a silicate, combining with the silicic acid of the sand.

**Cement** or hydraulic mortar is a mixture of powdered quartz, lime, and aluminum silicate; its hardening is due to the formation of calcium and aluminum silicates.

**Lime Water** or Liquor Calcis is a *clear* solution of calcium hydrate in water. Sugar increases the solubility of the calcium hydrate. Lime-water is a colorless, nearly odorless liquid, of feebly caustic taste and alkaline reaction. It is a solution of about 15 parts calcium hydrate in 10,000 of water.

*Milk of lime* is lime water containing an excess of calcium hydrate rendering it turbid.

Lime water is used in dentistry in form of gargle as an ant-acid, astringent, etc.

### 152. Calcium Fluoride.—

Synonyms: fluor-spar, fluoride of lime, Calcii Fluoridum.

Theoretical constitution:  $\text{CaF}_2$ , one atom of calcium and



two of fluorine, 40 parts by weight of calcium, and 38 of fluorine. Molecular weight, 78.

**Preparation:** calcium fluoride occurs in nature as fluor-spar; it is made artificially by treating a salt of calcium with potassium fluoride.

**Properties:** human bone contains about two per cent of calcium fluoride; the enamel of teeth contains it also. It is a very hard substance, insoluble in water, but decomposed by sulphuric acid, hydrofluoric acid being formed.

**153. Calcium Sulphite.**—Sulphite of lime, *Calcii Sulphis*. Formula  $\text{CaSO}_3$ ,  $2\text{H}_2\text{O}$ . Molecular weight, 156. Made by saturating milk of lime with sulphurous oxide, collecting and drying the precipitate. It is a white powder, but slightly soluble in water, soluble in sulphurous acid. It gradually becomes converted to sulphate. Used as an antiseptic.

**154. Calcium Sulphide.**—Obtained by calcining calcium sulphate with carbon.



It is a white, amorphous substance of alkaline reaction. It is an ingredient of luminous paints.

**155. Chlorinated Lime.**—Official name, *Calx Chlorata*. Contains probably  $\text{Ca}(\text{ClO})_2$ , calcium hypochlorite. It should yield 25 per cent. chlorine on addition of acid. It is prepared by the action of chlorine on calcium hydrate. It is a white or grayish-white, dry or but slightly damp powder or friable lumps, of feeble chlorine like odor, and disagreeable, saline taste. It should be kept in well-closed vessels, in a cool, dry place. It is partially soluble in water and in alcohol. It is a disinfectant and a bleaching agent. It is used in dentistry as a deodorizer, disinfectant, antiseptic, and bleaching agent. It is poisonous in large doses.

**156. Calcium Phosphate.**— $\text{Ca}_3(\text{PO}_4)_2$ , basic phosphate, tricalcic phosphate, bone phosphate; found in whole organism, constitutes two-thirds of the teeth, found in bones, *calculi*; in the ash of albuminous substances; white, insoluble. Readily soluble in acid solutions.

**157. Calcium Hypophosphite.**— $\text{Ca}(\text{H}_2\text{PO}_2)_2 = 170$ . Prepared by dissolving phosphorus in milk of lime by aid of heat. Is a white salt, permanent in air, soluble in water, insoluble in alcohol.

**158. Magnesium.**—

Symbol, *Mg*. Atomic weight, 24. Sp. gr., 1.74.

It is a brilliant, silver white metal, lighter than silver, tar-

nishing in damp air, burning easily and with a flame of dazzling brightness. It is soluble in dilute acids and it unites directly with most of the negative elements.

TABLE 15—COMPOUNDS OF MAGNESIUM.

Name.	Formula.	Properties, Uses, etc.
Chloride	$\text{MgCl}_2$	White, soluble, very bitter.
Oxide	$\text{MgO}$	Known as magnesia or calcined magnesia. White, infusible, antacid, antidote to arsenic and caustic acids.
Sulphate	$\text{MgSO}_4$	"Epsom salt." White, soluble, very bitter.
Phosphate	$\text{Mg}_3(\text{PO}_4)_2$	Found in body along with calcium phosphate.
Ammonio-magnesium phosphate	$\text{MgNH}_4\text{PO}_4$	Called triple phosphate. Very soluble in acids, insoluble in alkalis.
Hypochlorite	$\text{Mg}(\text{ClO})_2$	Used for bleaching purposes.

### 159. Magnesium Carbonate.—

Synonyms: carbonate of magnesia, magnesia alba, salis amari. Official name, Magnesii Carbonas.

Formula,  $4\text{MgCO}_3 \cdot \text{Mg}(\text{HO})_2 \cdot \text{Aq}$ .

Two kinds are known to pharmacy, the "heavy" and the "light". Both are prepared by dissolving 25 parts of magnesium sulphate and 20 of sodium carbonate, each separately, in water, but the "light" carbonate is the result of mixing the solutions when cold, the "heavy" by dissolving in hot water and mixing while hot. There are certain other differences also in the methods of preparation, the light carbonate solution being much more dilute than the heavy. The light carbonate contains more carbonate and less hydrate, is about three times as bulky and is partly crystalline. The heavy carbonate is wholly amorphous. Both form a light, white mass or powder, nearly insoluble in water, but readily soluble in dilute acids.

### 160. Arsenic.—

Metallic arsenic is not used in medicine nor dentistry. One of its compounds, *arsenous oxide* or *anhydride*, is of importance and the term **arsenic** is usually applied to this substance.

**Arsenous Anhydride.—**

Synonyms: arsenious acid, arsenious anhydride, white arsenic, ratsbane, white oxide of arsenic, Arseniosum Oxidum. Official name, Acidum Arsenosum.

Theoretical constitution:  $\text{As}_2\text{O}_3$ , arsenous oxide, two atoms of arsenic to three of oxygen, by weight 150 of arsenic to 48 of oxygen. Molecular weight, 198. Composed of 75.76 per cent. As and 24.24 per cent. O. [The molecule of vitreous arsenic is thought to be represented by the formula  $\text{As}_4\text{O}_6$ ].

Preparation: arsenious oxide occurs in nature as arsenic "bloom" a term derived from the Saxon *bloma* a lump. It is obtained by roasting ores of other metals containing it, in a current of air. The arsenious oxide in the roasting process volatilizes and is condensed in suitable receiving chambers as a white powder.

Properties: it is found in the form of a fine, white, heavy powder or in glassy looking lumps. The powder is somewhat gritty, odorless, tasteless, permanent in air. Condensed from sublimation at  $752^\circ\text{F}$ ., it is a transparent, vitreous mass, sp. gr. 3.738. When condensed at temperature slightly less, crystallizes in right rhombic prisms. Vitreous arsenic, on keeping, gradually becomes opaque and crystalline. When condensed at  $392^\circ\text{F}$ ., it occurs in octohedral crystals, sp. gr., 3.69. This form is also obtained on evaporating a saturated aqueous solution. Vitreous arsenic is slightly more soluble than the opaque; 100 parts boiling water, dissolve 12 parts of the vitreous; on cooling, about three parts are left in solution. Arsenic is soluble in hot  $\text{HCl}$ , in solutions of alkalies and of tartaric acid. Dissolved in acids it forms a binary compound of arsenic, as arsenious chloride in hydrochloric acid. Dissolved in alkalies it acts as the negative element forming arsenites of the alkali metals, as  $\text{K}_2\text{HAsO}_3$ .

Locally, it acts as an escharotic, first destroying the vitality of organic structure, decomposition then ensuing.

It is a powerful antiseptic, retarding putrefaction to marked degree.

Uses in dentistry: arsenious oxide is used to destroy the vitality of tooth pulps; it has also been used as an obtunding agent. It kills a tooth by causing irritation; there is increased flow of blood to the parts, the arteries are enlarged so that there is no return of blood through the veins, hence strangulation at apex of the tooth.

Toxicology: arsenic in doses of from one to two grains is a

powerful poison. It is poisonous also even when locally applied. There is danger of absorption when arsenic is applied to the teeth.

The treatment of poisoning by this agent, when administered internally, is to provoke or promote vomiting by giving large quantities of hot milk and water or emetics of sulphate of zinc, or mustard; subcutaneous injection of apomorphine hydrochlorate in doses of  $\frac{1}{5}$  to  $\frac{1}{10}$  of a grain will speedily bring about emesis. The *antidote* to arsenic is ferric hydrate conveniently made by adding aqua ammoniæ to tincture of ferric chloride. A brownish substance is formed which, separated from the liquid, may be given *ad lib.* The antidote should be given after vomiting has been brought about. Finally bland liquids, such as milk and eggs should be given; sugar and magnesia in milk are highly recommended. Where arsenic has been absorbed from local application it is of course useless to give emetics, etc., the only treatment possible being that of treating the symptoms as they appear, promoting elimination by diuretics as potassium nitrate, etc., etc.

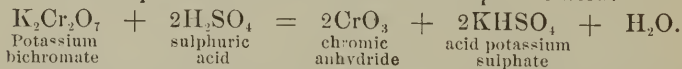
Note: in making the antidote for arsenic let the precipitate drain on a wetted muslin strainer until most of the liquid has run off, gather up the cloth, press it with the hands until no more liquid can be squeezed out, then add water and administer. The official hydrate is made from solution of normal ferric sulphate.

#### 161. Compounds of Chromium. Chromic Anhydride.—

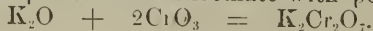
Synonyms: chromic trioxide, chromic oxide, chromic acid. Official name, Acidum Chromicum.

Theoretical constitution: chromic "acid" so-called is not an acid but an oxide,  $\text{CrO}_3$ , composed of one atom of chromium to three of oxygen; by weight, 52 parts of chromium to 48 of oxygen. Molecular weight, 100.

Preparation: chromic anhydride separates in crystals from a mixture of potassium bichromate and sulphuric acid:



Properties: fine red, very deliquescent, needle-shaped crystals. Strongly corrosive in action on organic matter. Decompose certain substances with explosive violence as alcohol, sugar, or glycerine. Form bichromates with oxides of the alkali metals as potassium bichromate with potassium oxide:



The crystals are readily soluble in water, forming an orange yellow solution of strongly acid properties. Alcohol is inflamed by the crystals.

Dental uses, etc.: used in dentistry locally, for removal of tumors, morbid growths, etc., etc. If combined with glycerine, care must be taken not to mix too rapidly, but drop by drop to avoid explosion. It penetrates tissues deeply, and does not cause much pain.

Toxicology: chromic acid is a poison, and one of the worst corrosive agents known; it destroys whatever it touches. Poisoning by it should be treated promptly and with vigor as in case of poisoning by sulphuric acid. Cause the patient to drink at once water containing 300 to 400 grains of magnesia, or else half an ounce of soap which has been dissolved in two quarts of hot water and cooled, or water with which wood ashes have mixed, or a solution of sodium bicarbonate (150 grains in a pint of water). If nothing else is at hand give milk or the whites of four eggs in a quart of water. Burns from it should be treated as in case of sulphuric acid, and as promptly as possible.

## CHAPTER VI.

### METALLURGY.

162. **Metals and their Properties.**—Metals are, as has already been seen, elementary bodies, solids with exception of mercury, insoluble in water, and possessed of certain properties as lustre, fusibility, etc. Among the more important properties of metals we find

*lustre*,—power of reflecting light;

*tenacity*,—resistance to any attempt to pull asunder their particles;

*malleability*,—capability of being hammered or rolled into thin sheets;

*ductility*,—property of being drawn out into wire;

*high specific gravity*,—or weight relative to water;

*high conducting power*,—for heat and electricity;

*fusibility*,—property of becoming liquid when heated;

*capacity for heat*, or specific heat;

*expansibility*,—property of expanding when heated;

*crystalline structure*,—shown by metals on cooling from fusion;

*volatility*,—property of being converted into vapor;

*color*;

*odor and taste*.

163. **The most lustrous metals** are gold, silver, platinum, palladium, steel, aluminum; zinc and lead are inferior in lustre; tin is naturally a brilliant metal but not hard enough to be polished like steel.

164. **The specific heat of metals** is the amount of heat necessary to raise equal weights of different ones, from the same given temperature to another given temperature. Water is assumed as the standard, and we find that the capacity for

heat of the different metals is in the following order: iron, nickel, cobalt, zinc, copper, palladium, silver, cadmium, tin, antimony, gold, lead, platinum, bismuth. Suppose now, a cubic inch of iron and a cubic inch of tin were both heated to the same temperature for the same time and placed each on a cake of paraffine, which would melt its cake the sooner? Iron, because its capacity for heat is greater than that of tin.

165. **All metals are somewhat volatile:** some are noticeably volatile, as mercury, arsenic; others to a limited extent, and a few with difficulty even at highest temperatures. Gold is somewhat volatile when alloyed with certain metals.

166. **The characteristic color of metals** ranges from pure white to bluish. A few metals, as iron, copper, and zinc have an odor, especially when heated.

167. **The noble metals** are mercury, silver, gold, platinum, palladium, rhodium, ruthenium, osmium, iridium; they may be separated from their oxides by merely heating to redness.

168. **The decomposition of acids** by metals and replacement of hydrogen has already been alluded to.

169. **Metals are opaque**, except gold when in thin leaves.

170. A complete list of **elementary substances**, as far as is authentic is now given, the names of those used as true metals being printed in small capitals, other important metals used, for example, in medicine, the arts, etc., in heavy-faced type, rare metals in italics, non-metals in ordinary type.

TABLE NO. 16.

Element.	Symbol.	Atomic wt.
ALUMINIUM.....	Al.....	27
Antimony (used as a METAL).....	Sb.....	120
Arsenic (used in <b>medicine</b> ).....	As.....	74.9
<b>Barium</b> .....	Ba.....	136.8
<i>Beryllium</i> ( <i>Glucinum</i> ).....	Be.....	9
BISMUTH.....	Bi.....	210
Boron.....	B.....	11
Bromine.....	Br.....	79.8
CADMIUM.....	Cd.....	111.8
<i>Cesium</i> .....	Cs.....	132.6
<b>Calcium</b> .....	Ca.....	40
Carbon.....	C.....	12
<i>Cerium</i> .....	Ce.....	141
Chlorine.....	Cl.....	35.4
<b>Chromium</b> .....	Cr.....	52.4
<b>Cobalt</b> .....	Co.....	58.9
COPPER.....	Cu.....	63.2
<i>Didymium</i> .....	D.....	144.6



TABLE NO. 16—*Continued.*

Element.	Symbol.	Atomic wt.
<i>Erbium</i> .....	E.....	165.9
Fluorine.....	F.....	19
<i>Gallium</i> .....	G.....	68.8
GOLD.....	Au.....	196.2
Hydrogen.....	H.....	1
<i>Indium</i> .....	In.....	113.4
Iodine.....	I.....	126.6
<i>Iridium</i> .....	Ir.....	192.7
IRON.....	Fe.....	55.9
<i>Lanthanum</i> .....	La.....	138.5
LEAD.....	Pb.....	206.5
<b>Lithium</b> .....	Li.....	7
MAGNESIUM.....	Mg.....	24
<b>Manganese</b> .....	Mn.....	54
MERCURY.....	Hg.....	199.7
<i>Molybdenum</i> .....	Mo.....	95.5
NICKEL.....	Ni.....	58
<i>Niobium</i> .....	Nb.....	94
Nitrogen.....	N.....	14
<i>Osmium</i> .....	Os.....	198.5
Oxygen.....	O.....	16
<i>Palladium</i> .....	Pd.....	105.7
Phosphorus.....	P.....	31
PLATINUM.....	Pt.....	194.4
<b>Potassium</b> .....	K.....	39
<i>Rhodium</i> .....	Rh.....	104.1
<i>Rubidium</i> .....	Rb.....	85.3
<i>Ruthenium</i> .....	Ru.....	104.2
<i>Scandium</i> .....	Sc.....	44
Selenium.....	Se.....	78.8
Silicon.....	Si.....	28
SILVER.....	Ag.....	107.7
<b>Sodium</b> .....	Na.....	23
<i>Strontium</i> .....	Sr.....	87.4
Sulphur.....	S.....	32
<i>Tantalum</i> .....	Ta.....	182
Tellurium.....	Te.....	128
<i>Thallium</i> .....	Tl.....	203.7
<i>Thorium</i> .....	Th.....	233
TIN.....	Sn.....	117.7
<b>Titanium</b> .....	Ti.....	48
<i>Tungsten</i> .....	W ( <i>Wolframium</i> ).....	183.6
<b>Uranium</b> .....	U.....	238.5
<i>Vanadium</i> .....	V.....	51.3
<i>Ytterbium</i> .....	Yb.....	172.7
<i>Yttrium</i> .....	Y.....	89.8
ZINC.....	Zn.....	64.9
<i>Zirconium</i> .....	Zr.....	90

171. The elements used as true metals will be arranged with reference to their symbols, *Latin names, equivalence,*

*specific gravity*, etc., etc., etc., a list of which is here given with definitions and such explanation as is deemed necessary.

*Symbol*: an abbreviation used to designate a chemical element: often the first letter or letters of its Latin name.

*Latin names of the metals*: usually end in -um, and are often quite different from the English name.

*Equivalence*: quantity of combining or replacing power of an elemental atom, expressed in hydrogen units: thus, as one atom of gold unites with three of hydrogen, gold is said to have an equivalence of three.

*Specific gravity*: weight of a certain bulk of a substance compared with the same bulk of water: thus, as lead weighs 11 times as much as water, it is said to have a sp. gr. of 11.

*Atomic weight*: weight of an atom of an element, compared with one atom of hydrogen; the smallest quantity of an element by weight which can take part in the formation of a chemical compound. An atom of oxygen is 16 times heavier than an atom of hydrogen, hence the atomic weight of oxygen is said to be 16. [These weights are ascertained by analysis and from knowledge of molecular weights, which latter are obtained by multiplying the density of an element in state of gas by the molecular weight of hydrogen].

*Revised atomic weight*: the atomic weights are given in approximate figures; the revised atomic weights are more accurate.

*Electrical state*: when a metallic compound is broken up by passage of an electrical current through it, the elements of which the compound is composed are called *positive*, if they collect at the negative pole, and *negative*, if at the positive pole. The term *positive* is denoted by the sign +; the term *negative* by the sign —. When water is decomposed by passing electricity through it, the hydrogen gas collects at the negative pole and the oxygen at the positive; hydrogen is therefore positive to oxygen.

*Fusing point*: the temperature at which the various metals melt and become liquid. Lead melts at 617° Fahrenheit, hence its fusing point is said to be 617°.

*Length of bar at 212° F.*, which measures 1 at 32° F. It is well-known that heat expands metals; thus, a bar of aluminum which at 32° F. is 1 foot long, at 212° F. will be  $1 \frac{22}{10,000}$  foot. In the tabulated statements concerning length of bar in metals, fourteen, namely: aluminum, antimony, bismuth, cadmium, copper, gold, iron, lead, magnesium, palladium,

platinum, silver, tin, and zinc are considered. Given any unit of measurement then, whether an inch, a foot, etc., etc., at 212° F. there will be a certain gain in length of the bar. It must, however, be remembered that, for the same kind of metal, the greater its specific gravity the greater its expansion for a given increase in temperature.

*Tensile strength* is the resistance of the fibres or particles of a body to separation, and the amount of weight or power required to tear asunder one square inch of a metal is given, in figures, in tons; thus, the tensile strength of iron (wrought) is said to be 29. This means that a weight of 29 tons, or a power equivalent to 29 tons, is necessary to tear asunder one square inch of the metal.

*Tenacity*: the metals are compared as regards tenacity with lead, which is the weakest; the tenacity of copper is said to be 18, which means that it is 18 times *more tenacious* than lead; copper is said to be in "3d rank," because of the ten metals, steel, iron, copper, platinum, silver, gold, palladium, zinc, tin, lead, there are only two more tenacious. Care should be taken to note that the "rank" of a metal is strictly relative, and, unless the metals with which it is compared be known, the idea conveyed by the term is wholly vague.

*Malleability*: the metals are compared with *gold*, which is the most malleable; *eight* metals in all are compared, namely: gold, silver, copper, tin, platinum, lead, zinc, iron. The malleability of zinc is said to be 7, which means that there are six metals more malleable; its rank therefore among the eight is 7th.

*Ductility*: the standard is gold, which is the most ductile. Ten metals are compared: gold, silver, platinum, iron, copper, palladium, aluminum, zinc, tin, iron. The ductility of zinc is said to be 8, which means that seven of the ten metals are more ductile. It is therefore 8th in rank. *It will be noticed that the comparison in regard to tenacity is made differently from either that in regard to malleability or to ductility.*

*Conducting power* with reference to heat: the metals are compared with silver, which is the best conductor and *eleven* metals in all are considered: the conducting power of zinc is said to be 5, which means that four metals are better conductors; it is therefore 5th in rank.

*Conducting power* with reference to electricity: the metals are compared with silver, which is the best conductor of electricity. *Twelve* metals are considered, namely: silver, gold,

copper, zinc, palladium, platinum, iron, nickel, tin, lead, antimony, bismuth. The conducting power of zinc for electricity is 290, silver being taken as 1,000 in conducting power. In other words, silver is  $\frac{1000}{290}$  or 3.44 times a better conductor than zinc. But zinc is 4th in rank among the twelve, for only three are better conductors of electricity.

*Resistance to air, etc.:* resistance to dry, pure air is one thing, but resistance to air containing moisture, carbonic acid, etc., is quite another. Under this head also, is mentioned the effect of sulphuretted hydrogen on the metal.

*Solubility:* under this head the best solvents for the metal are given, that is, substances having the power, like acids, to attack the metal and convert it into a liquid.

*Direct combinations:* under this heading is given a list of substances which unite directly with the metal, either in the cold or when heated, rubbed, or triturated with it, without the intervention of oxygen.

*Structure:* many of the metals have a crystalline structure, *i. e.*, when small particles of them are seen under the microscope, certain definite geometrical shapes are observed as cubes, rhombohedrons, etc. The form in which iron tends to crystallize is a regular octahedron: an eight-sided figure with equal axes at right angles to one another. Crystalline forms are classified into six systems. (See Chap. I). Many of the metals are to be found in the first or *isometric* system, in which there are three axes of equal length, and at right angles to each other, as in case of the cube and the octahedron. Copper crystals are examples of the isometric system.

*Compounds:* the metals form various compounds according to their equivalence, and Latin names are often used instead of English: for example, iron as a dyad, uniting with other elements, forms *ferrous* compounds; silver compounds are sometimes called *argentic*, as *argentic nitrate*, etc., etc.

**Value in Dental Amalgam Alloys:** the relative value of the metals in dental amalgam alloys is given, when possible, according to Flagg.

172. TABLE NO. 17—NAMES AND PROPERTIES OF THE MORE IMPORTANT METALS.

Names.	Sp. gr.	Fusing Point; approximate Fahrenheit.	Weight of One Cubic Foot in Pounds.	Tensile Str'gh per sq. in. in tons.
*Aluminium.....	2.67	1292°	166.8	12
Antimony.....	6.72	1150°	419.5	0.5
Bismuth.....	9.82	507°	613.0	1.5
*Cadmium.....	8.69	442°	542.5	
*Cobalt.....	8.95	less than iron	558.7	same as iron
*Copper.....	8.94	1996°	558.1	13 to 15
*Gold.....	19.36	2016°	1208.6	9.1
*Iron.....	7.84	3500°	489.4	29 (maximum)
Lead.....	11.36	617°	709.2	0.8 to 1.5
Magnesium.....	1.74	850°	108.6	
Manganese.....	8.01	less than iron	500.0	
Mercury.....	13.59	—39°	848.4	
*Nickel.....	8.67	less than iron	541.2	same as iron
*Palladium.....	11.8	same as iron	736.6	
*Platinum.....	21.53	greater than iron	1344.0	
Silver.....	10.53	1873°	657.3	18.2
Tin.....	7.29	442°	455.1	2 to 3.5
*Zinc.....	7.14	773°	445.7	3.3 to 8.3

N. B.—The star \* refers to the wrought metal. Mercury, tin, cadmium, bismuth, lead, and zinc, are all fusible *below* red heat. Antimony, just below red heat. Silver, copper, gold, and aluminium, at bright red heat. Iron, cobalt, manganese, and palladium, at highest forge heat. Osmium, iridium, platinum, at heat of oxy-hydrogen blowpipe. Steel is to be melted in a furnace of special construction, called a wind furnace.

TABLE NO. 18—TENACITY, RELATIVE MALLEABILITY, AND DUCTILITY OF THE MORE IMPORTANT METALS.

Name.	Tenacity.	Malleability.	Ductility.
Lead.....	1	6	10
Cadmium.....	1.2		
Tin.....	1.33	4	9
Zinc.....	2	7	8
Palladium.....	11.5	(10)	6
Gold.....	12	1	1
Silver.....	12.5	2	2
Platinum.....	15	5	3
Copper.....	18	3	5
Iron.....	27.5	8	4
Steel.....	42		
Aluminum.....			7

Explanation: *tenacity*: if the weight required to pull asunder a wire of lead be taken as a standard and called 1, the

weight required to pull asunder a wire of cadmium would be a little more, namely 1.2; that to pull asunder a wire of steel, for example, 42 times as much as the lead. *Malleability*: if the difficulty with which a mass of gold can be hammered or rolled into a thin sheet, without being torn, be represented by 1, iron will be found to be 8 times as difficult. *Ductility*: if the difficulty with which gold can be drawn into a wire be represented by 1, tin for example will be drawn with 9 times the the difficulty.

TABLE NO. 19—CONDUCTING POWERS OF METALS.

Name.	Heat.	Electricity.
Silver.....	1	1000 (standard),
Gold.....	2	779, (3d)
Copper.....	3	999, (2d)
Aluminum.....	4	
Zinc.....	5	290, (4th)
Iron.....	6	168, (7th)
Tin.....	7	123, (9th)
Platinum.....	8	180, (6th)
Lead.....	9	83, (10th)
Antimony.....	10	46, (11th)
Bismuth.....	11	12, (12th)
Palladium.....		184, (5th)
Nickel ..		131, (8th)

Explanation: in the table under *heat*, the metals are arranged in the order of their conducting power, silver being the best, gold next, etc., etc. In the table under *electricity*, silver is taken as the standard, as it is the best conductor of electricity, and the other metals are compared with it, in the pure state at 32°F. In some works, gold is given 3d place in heat-conducting power, copper 2nd.

173. **Properties of Metals, and uses:** mercury is useful for *amalgamating* or dissolving other metals; antimony has the property of hardening lead and tin, when melted with them; bismuth and cadmium make tin capable of being melted at lower temperatures; nickel whitens copper, and is used in the manufacture of German silver. Gold, platinum, palladium, silver are limited in use by their high price, and the same is true to a certain extent of aluminum, although the price of this metal is much lower now than formerly. Zinc has a comparatively high degree of expansibility; gold is the most malleable of metals as also the most ductile, silver is the best conductor of heat and electricity; the tenacity of metals is *usually* dimin-



ished by heating; malleability and ductility are developed in some metals by heating, but impaired by carrying heat too far; in alloys, heating impairs tenacity, malleability, and ductility; crystalline metals, as bismuth, lack malleability, etc.; metals may be obtained in crystalline form by electrolysis, either by introducing other metals in strips or rods into their solutions, as a rod of zinc into a solution of a lead salt, or by passage of a weak electric current through their solutions. Gold may be obtained in crystalline form by introduction of a stick of phosphorus into a solution of one of its salts.

#### 174. **Silver.**—

Symbol: Ag.

Latin name: Argentum.

Equivalence: I and III.

Specific gravity: 10.40 to 10.57.

Atomic weight: 108.

Revised atomic weight: 107.675.

Electrical state: +

Fusing point: 1873°F. Expands on solidifying.

Length of bar at 212°: 1.0021; (6th rank).

Wt. of cubic ft. in lbs: 657.3.

Tensile strength: 18.2; (lead = 1).

Tenacity: 12.5\*; (5th rank).

Malleability: 2; (2d rank).

Ductility: 2; (2d rank).

Conducting power, heat: 1; (1st rank).

Conducting power, electricity: 1; (1st rank).

Resistance to air, etc.: tarnished by sulphuretted hydrogen, but not affected by air.

Solubility: in nitric acid, hot strong sulphuric, hydrochloric with difficulty; not attacked by caustic alkalies nor by melted nitre. It is dissolved by mercury.

Direct combinations: with halogens, chlorine, bromine, etc., and with sulphur and phosphorus.

Color and appearance: white, brilliant.

Structure: isometric crystals, when cooled slowly from fusion.

Consistence: soft. Intermediate in hardness between gold and copper.

Compounds: argentic, as argentic nitrate, etc.

Value in dental amalgam alloys: 1.

Ordinary alloys: silver coins, gold solders, silver solders, silver vessels, silver jewelry.

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\* Compared with lead.



Occurrence: silver is found in combination with some of the halogens as chlorine, bromine, iodine, with various other non-metals as sulphur, arsenic, antimony, and with copper. It occurs in the Western states, in Mexico, Saxony, Hungary, Norway, South America and elsewhere. It is sometimes found *native*.

Preparation: the methods are various and elaborate. The Washoe process is to grind the ores with water, in iron pans heated by steam. Mercury is added, the sulphide of silver is decomposed by the iron, sulphide of iron formed and metallic silver set free, dissolved in mercury and the mercury separated by pressure and distillation.

Pure silver may be prepared by reducing the chloride, by fusing it with dry sodium carbonate. Other methods are also used: one is to dissolve standard or other grades of silver in slightly diluted nitric acid, precipitate the solution by excess of common salt, place the well-washed chloride in water acidulated with hydrochloric acid, and add a few pieces of clean wrought iron; hydrogen is evolved which, uniting with the chlorine of the silver chloride, leaves the silver as a spongy mass. After the removal of the iron and decantation of the liquid, the silver is well washed in hot water containing a little hydrochloric acid, dried, and melted.

Uses in dentistry: silver is used in amalgam alloys and, according to Flagg, is the first, most important, and essential metal of a good amalgam alloy for filling teeth; it is the largest component of every truly good "submarine," "usual," or "contour" alloy in the market. Its presence in an amalgam is essential to proper setting; it notably maintains the bulk integrity of the filling; though discolored by sulphuretted hydrogen, the silver sulphide formed is highly conducive to the permanent saving of teeth largely decayed and predisposed to continued decay. Silver has also been used in dental plates.

175. Compounds of silver.

**Silver Nitrate or Argentic Nitrate.**—

Synonyms: lunar caustic, lapis infernalis. Official name, Argenti Nitras.

Theoretical constitution:  $\text{AgNO}_3$ , one atom of silver, one of nitrogen, three of oxygen, by weight 107.7 parts silver, nitrogen 14, oxygen 48. Molecular weight, 169.7.

Properties and uses: on evaporating a solution of silver in nitric acid and water, the nitrate of silver is obtained in the

form of colorless, heavy, shining, rhombic plates. It is blackened by exposure to light, and by contact with organic matter. It is also prepared in stick form, by fusing and pouring into moulds. It is very soluble in water, and slightly in alcohol. It is used in dentistry as an astringent, styptic, and obtunding agent. It blackens tissues with which it comes in contact, and is a powerful escharotic.

Should be kept in an amber bottle with a glass stopper.

Toxicology: silver nitrate is an irritant, corrosive, poison. The antidote is common salt or sal-ammoniac. Emetics should be given, and white of egg administered freely.

**Silver Sulphide.**—Silver has a strong affinity for sulphur, the sulphide,  $\text{Ag}_2\text{S}$ , being formed in the mouth by action of sulphuretted hydrogen on an alloy containing silver. Silver can therefore not be used in connection with substances containing sulphur, as rubbers. Silver sulphide is soluble in nitric acid, is soft and malleable.

**Silver Chloride,  $\text{AgCl}$ ,** is formed when either common salt or hydrochloric acid is added to a solution of silver nitrate.

176. **Zinc.**—

Symbol: Zn.

Latin name: Zincum.

Equivalence: II.

Specific gravity: 7.10 to 7.20.

Atomic weight: 65.

Revised atomic weight: 64.904.

Electrical state: +.

Fusing point:  $773^\circ$ .

Length of bar, etc.: 1.0029; (2d in rank, cadmium = 1).

Wt. of cubic ft. in lbs.: 445.7.

Tensile strength: 3.3 to 8.3.

Tenacity: 2; (8th rank).

Malleability: 7; (7th rank). Brittle, until heated to between  $248^\circ$  and  $302^\circ$  F.

Ductility: 8; (8th rank).

Conducting power (heat): 5; (5th rank).

Conducting power (electricity): 290 (silver = 1000); (4th rank).

Resistance to air, etc: tarnishes slowly; in moist air becomes coated with carbonate.

Solubility: soluble in dilute acids, and in solutions of alkaline hydrates; slowly corroded by water, milk, and wine.

Direct combinations: oxygen, chlorine. With iron, when heated to fusion.

Color and appearance: bluish white.

Structure: crystalline; form, rhombohedral.

Consistence: brittle.

Compounds: zinc as zinc sulphide, zinc chloride, etc.

Alloys: brass, bronze, bell metal, German silver, Aich's metal, arguzoid, Dutch metal, electrum, Muntz's metal, solders, sterro-metal, tutenag.

Value in dental amalgam alloys: 3.

**Occurrence:** zinc is found usually either as sulphide, *zincblende*,  $\text{ZnS}$ , or as carbonate, *calamine*,  $\text{ZnCO}_3$ . It is also found as silicate and as oxide. Blende is found in Great Britain, Saxony, Aix-la-Chapelle, and in North America. Calamine occurs in Great Britain, Aix-la-Chappelle, Silesia, Spain, and in many other places. Red zinc ore or oxide is found chiefly in New Jersey.

**Preparation:** zinc is converted into vapor with comparative facility; it boils and distills at bright red heat. Hence in order to extract zinc from its ores, the latter are first *calcined*, that is ignited in the air so as to burn off any oxidizable material, and the zinc obtained in form of oxide. The latter is then mixed with carbon and distilled, carbonic acid gas and zinc vapor being formed; the zinc vapor is condensed in suitable receivers.

Uses in dentistry: under ordinary circumstances zinc is brittle, but when heated to about  $300^\circ \text{F}$ ., it becomes malleable and ductile, and may be rolled into thin sheets. At about  $400^\circ \text{F}$ ., it becomes brittle, melts at  $775^\circ$ , and at  $1842^\circ$  boils, volatilizes, and burns, if air be not excluded, with a fine greenish-white light, the oxide being formed.

*Galvanized iron* is iron covered with a coating of metallic zinc.

According to Flagg, zinc, in proportion of from 1 to  $1\frac{1}{2}$  parts in 100, if added to the usual 40 silver 60 tin alloys, seems to control shrinkage, imparts a "buttery" plasticity to the amalgam, adds to the whiteness of the filling, and assists in maintaining its color.

Zinc is used in making dies for swaging plates. It may be used, according to Essig, in making counter-dies. (See Essig's Dental Metallurgy, p. 221).

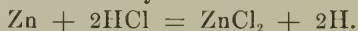
177. Compounds of zinc.

**Zinc Chloride.**—

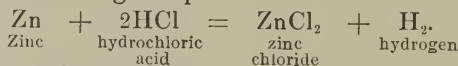
Synonyms: butter of zinc, muriate of zinc. Official name, *Zinci Chloridum*.

Theoretical constitution:  $\text{ZnCl}_2$ , one atom of zinc and two of chlorine in the molecule; by weight, 64.9 parts of zinc to 70.8 of chlorine. Molecular weight, 135.7. It contains 47.83 per cent. of zinc.

Preparation, properties and uses: zinc chloride is made by heating zinc in a current of chlorine, or by the action of hydrochloric acid on granulated zinc or zinc carbonate, and evaporation of the solution to dryness:



It occurs in the form of hard, dirty-white masses, very deliquescent, and forming a clear solution with water. Zinc chloride has a caustic, sharp taste and is acid in reaction. It is soluble in alcohol and in ether. "Burnett's Disinfecting Fluid" contains zinc chloride, in proportion of from 205 to 230 grains to the ounce of water. The official solution of chloride of zinc, *Liquor Zinci Chloridi*, is an aqueous solution of zinc chloride containing 50 per cent. of the latter, or 23.92 per cent. of zinc. It is made from 20 parts of granulated zinc, 1 part of nitric acid, 1 part of precipitated carbonate of zinc, and sufficient hydrochloric acid and distilled water. To the zinc, enough hydrochloric acid is added to dissolve it; the solution is filtered, nitric acid added, the whole evaporated to dryness, and the dry mass brought to fusion. After cooling, it is dissolved in 15 parts distilled water, the precipitated carbonate of zinc added, and the mixture agitated occasionally during the 24 hours. Finally it is filtered through washed asbestos free from iron, and enough distilled water added to it, through the filter, to make the product weigh 80 parts. The reaction is as follows:



The solution is evaporated to dryness, and the dry mass fused in order to remove any excess of nitric acid. Zinc chloride solution cannot be filtered through paper; powdered, washed glass or purified asbestos must be used.

The solution is a heavy, strongly caustic liquid, which should mix with alcohol without precipitation. Its sp. gr. is 1.555, and its sp. vol. 0.643.

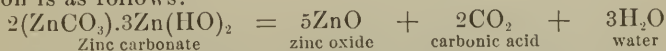
If of a sp. gr. of 1.1275 at 68° F., it contains only 13.876

per cent. of zinc chloride; if its sp. gr. is 1.2466 it contains 25.819 per cent; if 1.3869, 37.483 per cent.

Use in dentistry: zinc chloride is used in dental medicine for various purposes as an antiseptic, disinfectant, and deodorizer. A solution of it is used in connection with the oxide, to make a plastic filling (see zinc oxychloride).

Toxicology: chloride of zinc rapidly coagulates albumin. It is a caustic and irritant. Externally applied, it penetrates deeply into tissues and spreads, producing a white, thick and hard eschar. In cases of poisoning from internal administration, carbonate of sodium in milk, white of egg, or soap are the antidotes.

178. **Zinc Oxide.**—Official name, Zinci Oxidum.  $\text{ZnO} = 80.9$ . Made on a large scale by heating metallic zinc in a current of air. To make a pure white zinc oxide for pharmaceutical purposes, pure precipitated zinc carbonate should be heated at low red heat until the water and carbonic oxide are wholly expelled. This can be done below  $500^{\circ}\text{F}$ . The reaction is as follows:



Too high heat will give the product a yellow color, and make it feel harsh. A small quantity should be used in heating. A good quality of zinc oxide should come in the form of a soft, flaky, impalpable powder of sp. gr. 5.6. It should turn yellow when heated in a test tube, and become white again on cooling.

It is insoluble in water, but completely soluble in dilute acids. It is not darkened by sulphuretted hydrogen.

179. **Zinc Oxychloride.**—

Theoretical constitution: oxychlorides differ from chlorides, in that the former are *chlorides of the oxide of a metal*, while the latter are chlorides of the metal itself only. There are various oxychlorides of zinc, whose formulæ are as follows:

- (a)  $\text{ZnCl}_2.6\text{ZnO}.6\text{H}_2\text{O}$ ;
- (b)  $\text{ZnCl}_2.3\text{ZnO}.4\text{H}_2\text{O}$ ;
- (c)  $\text{ZnCl}_2.9\text{ZnO}.3\text{H}_2\text{O}$ .

It will be seen therefore that the general formula for the three is  $\text{ZnCl}_2.n\text{ZnO}.n\text{H}_2\text{O}$ ,  $n$  denoting any number.

*Method of preparation:* oxychlorides of zinc are prepared in various ways: the one used in dentistry is made, according to Flagg, by heating oxide of zinc with borax, adding gradually more calcined oxide of zinc, and finally mixing with

solution of chloride of zinc. (See chapter VII for complete process). Morsman prepares the oxychloride by a different process, which will also be found in Chapter VII.

*Properties and uses:* zinc oxychloride is a white substance, plastic when first mixed, but rapidly hardening with age.

It is used in dentistry for filling, "lining," and restoring color to discolored teeth.

#### 180. Zinc oxysulphate.—

Theoretical constitution: the mixture used in dentistry under this name is composed of a powder, consisting of one part of calcined zinc sulphate to two or three parts of calcined zinc oxide. Dissolved in a solution containing gum arabic and a little sulphite of lime, it forms a plastic mass soon setting and very dense when hard. (Flagg.)

Uses in dentistry: zinc oxysulphate is used in dentistry as an adjunct to filling materials. It adheres well to dentine. According to Flagg, it is perfectly non-irritating both to sensitive dentine and to dental pulp, is an astringent and antiphlogistic.

#### 181. Other compounds of zinc.—

**Zinc sulphate**,  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ : white vitriol, white copperas, Zinci Sulphas. Occurs in small, colorless, transparent, efflorescent crystals, often mistaken for Epsom salt. Astringent, emetic, irritant poison. Freely soluble in water, insoluble in alcohol. Disagreeable, metallic, styptic taste. Made by dissolving zinc in sulphuric acid:  $\text{Zn} + \text{H}_2\text{SO}_4 = \text{ZnSO}_4 + \text{H}_2$ .

**Zinc iodide**,  $\text{ZnI}_2 = 318.1$ . Official name, Zinci Iodidum. Made by digesting granulated zinc 30 Gm. (465 grains), iodine 100 Gm. (1550 grains), water 200 C.c. ( $6\frac{1}{2}$  fluid ounces) until colorless and free from odor of iodine, subsequently filtering through asbestos or powdered glass, and evaporating filtrate rapidly to dryness at moderate heat. Zinc iodide is a white, granular substance, very readily soluble in alcohol and in water.

Zinc iodo-chloride has also been used in dentistry.

Toxicology of zinc compounds: the general antidotes are alkaline carbonates, as sodium carbonate, white of egg, soap and water, and mucilaginous drinks.

#### 182. Cadmium.—

Symbol: Cd.

Latin name: Cadmium.

Equivalence: II.

Specific gravity: 8.69.



Atomic weight: 112. Molecule composed of one atom.

Revised atomic weight: 111.835.

Electric state: +.

Fusing point:  $442^{\circ}$  F.

Length of bar, etc.: 1.0031; (first in rank, most expansible).

Wt. of cubic ft. in lbs.: 542.5.

Tensile strength:

Tenacity: greater than tin.

Malleability: { flexible, malleable, and ductile.

Ductility:

Conducting power (heat).

Conducting power (electricity): somewhat lower than zinc.

Resistance to air: gradually tarnishes in air; stained yellow by sulphuretted hydrogen.

Solubility: soluble in nitric acid, in dilute hydrochloric, and sulphuric, but not in caustic alkalies.

Direct combinations:

Color and appearance: like tin; white tinged with blue; lustrous.

Structure: crystallizes in regular octahedrons on cooling.

Consistence: harder than tin; not so hard as zinc; soft enough to mark paper.

Compounds: cadmium, as cadmium sulphate.

Alloys: fusible metal.

Value in dental amalgam alloys: disputed.

Occurrence: cadmium often accompanies zinc in its ores, and occurs as an impurity in commercial zinc. It is found in small quantities, not over 2 or 3 per cent., in ores of zinc. It occurs most abundantly as sulphide.

Preparation: the metal is obtained by converting the sulphide into oxide by heat, and then reducing this with coal or charcoal.

Uses in dentistry: cadmium is a constituent of easily fusible alloys. It resembles tin in color and appearance, and *creaks* like the latter when bent. It is unalterable in the air. Flagg objects to the use of cadmium in amalgam alloys, on the ground that the fillings gradually soften and disintegrate, yellowish discoloration is apparent in adjoining tooth-structure, etc., etc. Cadmium resembles lead in many respects.

183. Compounds of Cadmium.

**Cadmium Sulphate:**  $3(\text{CdSO}_4) \cdot 8\text{H}_2\text{O}$ . Molecular weight, 768. Obtained by dissolving metallic cadmium, its oxide, or carbonate in sulphuric acid; if metallic cadmium is used, a



little nitric acid is added to hasten the reaction, and afterwards driven off by evaporation. Cadmium sulphate occurs in form of colorless, transparent crystals, resembling sulphate of zinc. In dentistry, it has been used in various injections and lotions. It is poisonous. Percentage of cadmium, 43.74.

#### 184. Lead.—

Symbol: Pb.

Latin name: Plumbum.

Equivalence: II. and IV.

Specific gravity: 11.33 to 11.39.

Atomic weight: 206.5.

Revised atomic weight: 206.4710.

Electrical state: +.

Fusing point: 617° F.

Length of bar, etc.: 1.0028 (3d rank, cadmium = 1, most expandible).

Wt. of cubic ft. in lbs.: 709.2.

Tensile strength: 0.8 to 1.5.

Tenacity: 1 (lowest in rank).

Malleability: 6; (6th rank).

Ductility: 10; (10th rank).

Conducting power (heat): 9; (9th rank).

Conducting power (electricity): 83, (silver = 1000); (10th rank).

Resistance to air, etc.: soon tarnishes; corroded by air in presence of carbonic acid. Discolored by sulphuretted hydrogen.

Solubility: soluble in dilute nitric acid; attacked by hot sulphuric.

Direct combinations: oxygen, chlorine, bromine, iodine, sulphur. Amalgamates readily.

Color and appearance: bluish-white, brilliant.

Structure: crystallizes in regular octahedrons, or in pyramids with four faces.

Consistence: soft, leaves mark on paper.

Compounds: mostly plumbic, so-called, Pb<sup>IV</sup>.

Alloys: solder, type metal, pewter, fusible metal; has affinity for platinum and palladium.

**Occurrence:** lead occurs in nature chiefly as galena or galenite which, like cinnabar, is a sulphide, PbS; 100 parts of the pure ore contains 86½ of lead. Another ore is *white-lead ore* or carbonate of lead. Galena is found in Great Britain, Spain, Saxony, and the United States. White lead ore is

found in the valley of the Mississippi; in Australia, an ore called Anglesite, which is a sulphate of lead, is found. Other ores are crocoisite (a chromate), Wulfenite (a molybdate), and pyromasphite (a phosphate).

**Preparation:** galena is roasted, during which process two products, lead oxide and lead sulphate, are formed; the two products thus obtained are then strongly heated in a reverberatory furnace, metallic lead and sulphurous oxide being formed.

**Dental uses:** lead alloys with other metals, and is an ingredient of various solders: common solder is 50 parts lead and 50 parts tin. Lead is used in dentistry chiefly in the making of counter-dies. [Thin sheets of it are used for making patterns by which gold or silver plate is cut, so that bits of it may be found in the dentist's gold drawer; a very small amount of it will greatly impair the ductility of gold].

185. **Compounds of Lead:** those of importance are the acetate, sub-acetate, and oleate, for which see Organic Chemistry.

186. **Mercury, (quicksilver).—**

Symbol: Hg.

Latin name: Hydrargyrum.

Equivalence:  $(\text{Hg}_2)^{11}$  and II.

Specific gravity: 13.596.

Atomic weight: 199.7. Molecule composed of one atom.

Revised atomic weight: 199.7120.

Electrical state: +.

Fusing point: liquid at ordinary temperatures. Boils at 660° F.

Length of bar: total expansion, 1.0180.

Wt. of cubic ft. in lbs.:

Tensile strength:

Tenacity, malleability, etc.: (liquid). Malleable at 40° F.

Conducting power, (heat):

Conducting power (electricity):

Resistance to air, etc.: unaltered in air; does not leave streak on paper.

Solubility: soluble in dilute nitric acid and hot sulphuric; insoluble in hydrochloric acid.

Direct combination: dissolves all metals but iron; combines directly with halogens and sulphur.

Color and appearance: opaque, with metallic lustre; brilliant, silver-white.

Structure: octahedral crystals at  $-40^{\circ}$  F.

Consistence: liquid; volatile.

Compounds: mercurous ( $\text{Hg}_2$ )<sup>II</sup> and mercuric.

Alloys: amalgams.

Value in dental amalgam alloys: mercury amalgamates readily with gold, zinc, tin, and silver; also with copper, platinum, palladium, and cadmium.

Occurrence and preparation: mercury is found in the form of **cinnabar**, which is native mercuric sulphide. Large quantities of it are obtained in California; it is also found in Spain, Austria, Mexico, Peru, China, Japan, Borneo. Mercury is obtained from cinnabar, either by roasting the latter or by heating it with lime which combines with the sulphur of the cinnabar, while the metal volatilizes and is condensed in suitable coolers.

The equation of the preparation of mercury is



**Dental uses:** amalgam: (see Chapter VII) mercury readily alloys with other metals, forming combinations called *amalgams*.

This property of mercury may be readily shown by the following experiment: clean a copper cent with a little nitric acid, wash well with water and on it place a globule of mercury; the latter soon covers the whole surface of the cent giving it a white color. Heat the cent and its original color will be restored, the mercury volatilizing. Many of the alloys of mercury with other metals are soft when freshly formed, but harden with time, hence their value for fillings.

#### 187. Compounds of Mercury:—

##### **Mercuric chloride or corrosive sublimate:**

Synonyms: corrosive chloride, bichloride of mercury, "oxymuriate" of mercury, perchloride of mercury, deuto-chloride of mercury, Hydrargyri Perchloridum Official name, Hydrargyri Chloridum Corrosivum.

Theoretical constitution:  $\text{HgCl}_2$  or mercuric chloride. Mercury as a *dyad*. The molecule is composed of one atom of mercury to two of chlorine; by weight, mercury 200 parts, chlorine 70.8. Molecular weight, 270.8. Percentage of mercury, 73.85.

Preparation (pharmaceutical): made by taking 20 parts of mercuric sulphate and 16 of sodium chloride, reducing each to fine powder, mixing well, adding 1 part of black oxide of man-

ganese in fine powder, triturating thoroughly in a mortar, and subliming:



The manganese oxide is added to oxidize any mercurous salt, which may be present in the mercuric sulphate.

Properties: corrosive sublimate occurs as a white, heavy powder, or as heavy, colorless, rhombic crystals or crystalline masses. It has a metallic, acrid taste, an acid reaction, and is a violent poison. Specific gravity, 5.4. It is soluble in 16 parts of cold water, and 2 of boiling, in about 2 of alcohol, and 4 of ether. Its ready solubility in alcohol should be noted, as many compounds of the metals are insoluble in alcohol, or less soluble in it than in water. It is a powerful germicide, an aqueous solution of 1 in 20000 destroying the spores of bacilli in ten minutes. A solution of 1 in 5000 is used as a disinfectant. Aqueous solutions gradually decompose on exposure to light or in contact with organic substances, such as sugar, gum, extracts, resin, etc. When mercuric chloride is powdered, it should be kept moist with alcohol to prevent the poisonous dust from rising.

Dental uses: mercuric chloride in 1 in 20000 solution—half a grain in twenty-one fluid ounces of water—is used as an antiseptic. As a germicide, 1 part in 2500 of water; 1 in 5000 as a disinfectant. It is used as a lotion, injection or gargle.

Toxicology: corrosive sublimate is a powerful, irritant poison, and external application of it has been often attended by fatal results. In poisoning from internal administration, white of egg in milk, or else wheat flour mixed with milk, should be given; vomiting should be encouraged by emetics. White of egg in milk should be administered two or three times daily for some weeks. If salivation is troublesome, gargles of chlorate of potash and of alum should be used. In chronic poisoning, ptyalism is a prominent symptom.

In chronic mercurial poisoning, the teeth are said to become brittle.

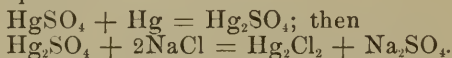
#### 188. Mercurous chloride or calomel:

Synonyms: mild chloride of mercury, subchloride of mercury, submuriate of mercury, Hydrargyri Subchloridum, protochloride of mercury. Official name, Hydrargyri Chloridum Mite.

Theoretical constitution:  $\text{Hg}_2\text{Cl}_2$ , two atoms of mercury (together bivalent) and two of chlorine; 400 parts by weight of

mercury, and 70.8 by weight of chlorine. Molecular weight, 470.8. Its formula is sometimes written  $\text{HgCl}$ .

Preparation: either (1) by subliming mercuric sulphate, 10 parts, with sodium chloride 5 parts, 7 parts of metallic mercury having been previously triturated with the moistened mercuric sulphate:



Mercurous sulphate and sodium chloride give mercurous chloride and sodium sulphate. Or (2) by precipitating a solution of 300 grams of mercury in 270 C c. of nitric acid (suitably diluted), with hydrochloric acid.

Properties: sublimed calomel is a fine, white powder, with very slight tinge of yellow. Tasteless, insoluble in both water and alcohol. Sp. gr., 6.56. Completely volatilized by heat. Precipitated calomel is bulkier than sublimated calomel. Exposed to sunlight it acquires a grayish tinge, becoming partially decomposed into metallic mercury and corrosive sublimate; boiled with water, the same change takes place slowly, and a mixture of it with sugar contains, after some time, an appreciable amount of the mercuric chloride. Mixed with water, it should give no white precipitate with ammonia. Given internally in sufficient quantity it produces salivation; cases are also on record where its external application produced salivation.

#### 189. Mercuric Sulphide.—

Synonyms: sulphide of mercury, cinnabar, vermilion.

Theoretical constitution:  $\text{HgS}$ , mercuric sulphide. Molecular weight, 231.7.

Preparation: it occurs as an ore and is then termed cinnabar. Made artificially, it is called vermilion. The latter is prepared, by the Chinese, by stirring a mixture of 1 part sulphur and 7 mercury in an iron pot, and heating in small lots to redness. Another method of preparing it is to digest the compound formed by triturating 300 parts of mercury with 114 of sulphur (moistened with a solution of caustic potash), at  $120^\circ\text{F}$ ., with 75 parts of caustic potash and 400 of water. (Essig).

[Essig thinks the discomfort sometimes caused by wearing vulcanized rubber artificial dentures due in part possibly to the presence of substances used to adulterate vermilion. Among these we find red lead, disulphide of arsenic, etc., etc. *Pure* vermilion, in combination with rubber, is not likely to cause trouble in the mouth, provided due cleanliness on part

of wearer be observed, and care and skill in construction used. The modified condition of that part of the surface of the mouth in contact with the rubber plate has been attributed to electrical action.]

190. **Other compounds of mercury.**—

**Mercuric iodide:**  $\text{HgI}_2$ , biniodide of mercury, deut-iodide, red iodide; formed when solution of potassium iodide is cautiously added to solution of mercuric chloride. Fine, heavy, crystalline, scarlet-red powder. Nearly insoluble in water, soluble in hot alcohol, in solution of KI (potassium iodide), and of NaCl (sodium chloride). Powerful irritant and caustic.

**Mercurous iodide:**  $\text{Hg}_2\text{I}_2$ , or  $\text{HgI}$ , prot iodide, yellow iodide, green iodide. Triturate mercury, iodine, and a little alcohol. Greenish yellow powder, insoluble in water, alcohol, and ether. Sunlight turns dark olive green, and partly decomposes it. Must not be given with KI, as  $\text{HgI}_2$  (mercuric iodide) is formed.

**Mercuric oxide:** (a) red precipitate, red oxide.  $\text{HgO}$ . Small, shining, red scales, acrid taste, insoluble, escharotic, stimulant.

**Mercuric oxide:** (b) Yellow oxide. ( $\text{HgO}$ ). Precipitate solution of  $\text{HgCl}_2$ , with KHO (potassium hydrate). Amorphous, yellow powder, more minute than red oxide. Insoluble. Turns to red oxide, when heated.

**Mercurous oxide:** black oxide, sub-oxide. Shake calomel with solution of KHO. Black, odorless, tasteless, insoluble. Decomposes on exposure to light. Used in mercurial fumigations. Least irritating oxide.

**Mercuric cyanide:**  $\text{HgCy}_2$ , or  $\text{HgC}_2\text{N}_2$ . (See Organic Chemistry.) Cyanuret of mercury. Receive hydrocyanic acid in vessel containing red oxide of mercury in water. Permanent, prismatic, white, opaque crystals, soluble in water *but sparingly in absolute alcohol*; disagreeable styptic taste; poisonous, like  $\text{HgCl}_2$ , but not so irritating in medicinal doses.

**Mercuric nitrate:**  $\text{Hg}(\text{NO}_3)_2$ . "Acid" nitrate of mercury.

**The Sulphates of mercury:** Hg boiled with  $\text{H}_2\text{SO}_4$  yields mercuric sulphate, forming with water an oxysulphate (Turpeth mineral); mercuric sulphate triturated with Hg yields mercurous sulphate,  $\text{Hg}_2\text{SO}_4$ .

**The Sulphides of mercury:** cinnabar or vermilion occurs in nature. The black sulphide, Æthiop's Mineral, formed, when solution of salt of mercury is precipitated by  $\text{H}_2\text{S}$ , or when Hg and S, are triturated.



**Ammoniated mercury:**  $\text{NH}_2 \text{HgCl}$ . Mercur-ammonium chloride. White precipitate. Precipitate solution of corrosive sublimate with ammonia. Perfectly white, insoluble.

**191. Copper.—**

Symbol: Cu.

Latin name: Cuprum.

Equivalence:  $(\text{Cu}_2)^{11}$  and II.

Specific gravity: 8.914 to 8.952.

Atomic weight: 63.4.

Revised atomic weight: 63.173.

Electrical state: +

Fusing point:  $1996^\circ\text{F}$ .

Length of bar, etc.: 1.0017; (7th in rank).

Weight of cubic foot in lbs.: 558.1.

Tensile strength: 13 to 15.

Tenacity: 18, (Lead = 1); (3d rank).

Malleability: 3; (3d rank).

Ductility: 5; (5th rank).

Conducting power (heat): 3; (3d rank).

Conducting power (electricity): 999, (Silver = 1000); (2d rank).

Resistance to air, etc.: in moist air coated with green carbonate. Tarnished by sulphuretted hydrogen.

Solubility: soluble in hot mineral acids, and attacked by vegetable acids in presence of air and moisture. Attacked by chlorine and nitric acid, and by sulphur when heated; slowly attacked by weak acids, alkalies, and saline solutions.

Direct combinations: sulphur, chlorine, bromine, iodine, silicon, and various metals at red heat.

Color and appearance: lustrous, flesh red.

Structure: crystallizes in isometric forms.

Consistence: somewhat softer than iron.

Compounds: cuprous  $(\text{Cu}_2)^{11}$  and cupric.

Alloys: Aich's metal, aluminium bronze, arguzoid, bell-metal, brass, Britannia metal, bronze, Dutch-metal, electrum, German silver, gold coinage, gun-metal, Muntz's metal, pewter, silver coinage, some solders, speculum metal, sterro-metal, tutenag.

Value in dental amalgam alloys: valuable for use in teeth with sensitive tendencies and predisposition to decay. (Flagg).

Occurrence: native copper exists near Lake Superior; in its



ores it is found as oxide, sulphide, carbonate, and in combination with sulphide of iron, forming copper pyrites. The metal is found in England, Sweden, Saxony, Siberia, Australia, Chili, and in the United States.

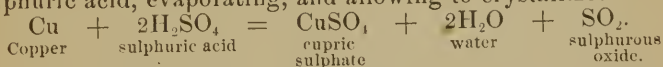
**Preparation:** the ores are first roasted in air, then with silica fluxes and carbon, and finally a substance called copperstone is obtained which contains both oxide and sulphide of copper. By repeating the roasting, and heating, the oxide reacts on the sulphide and metallic copper is obtained.

**Pure Copper** may be obtained by electrolysis. A solution of cupric sulphate is used, and the negative wire of a battery attached to a copper plate which is immersed in the solution. Pure copper is deposited on the plates, and may easily be stripped off.

**Use in dentistry:** copper is used as a constituent of some dental amalgam alloys. [Such alloys, in the mouth, become coated with cupric sulphide and the teeth are stained. It is claimed, however, that sensitive teeth and those naturally predisposed to decay are preserved by the copper salts formed].

#### 192. Compounds of Copper.—

**Cupric Sulphate:**  $\text{CuSO}_4, 5\text{H}_2\text{O}$ . Molecular weight, 249.2. Known as sulphate of copper, blue vitriol, Roman vitriol, blue stone, blue copperas, vitriol of copper. Official name, Cupri Sulphas. Made on a large scale by dissolving copper in sulphuric acid, evaporating, and allowing to crystallize:



It occurs in the form of blue, prismatic crystals, efflorescent, of astringent, metallic taste, soluble in 4 parts water, insoluble in alcohol. In dentistry, it is used in solution in ammonia, and externally, as an astringent, and styptic. It is poisonous: antidotes: milk, white of egg given freely. Chronic poisoning by copper salts has been noticed in cases where inferior gold has been used by dentists, for supports of artificial teeth. The action of the saliva produces soluble copper salts. The treatment in chronic poisoning is first to remove the cause, and then to treat the various symptoms as they appear.

#### 193. Tellurium.— \*

Symbol: Te.

Latin name: Tellurium.

Equivalence: II, IV, VI.

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\*Classified for convenience in this chapter.

Specific Gravity: 6.18—6.24.

Atomic weight: 128.

Revised atomic weight: 127.960.

Electrical state: —

Fusing point:

Length of bar:

Weight of cubic foot in lbs:

Tensile strength:

Tenacity:

Malleability:

Ductility:

Conducting power (heat): bad conductor.

Conducting power (electricity): bad conductor.

Resistance to air, etc.:

Solubility: soluble in hot sulphuric acid, in hot caustic alkali solutions; attacked by hot nitric acid.

Direct combinations:

Color and appearance: silver white.

Structure: crystallizes in rhombohedrons; like As and Sb.

Consistence: hard and brittle.

Compounds: tellurides; telluric, tellurous.

Alloys:

Value in dental amalgam alloys:

194. **Gold.**—

Symbol: Au.

Latin name: Aurum.

Equivalence: I, III.

Specific gravity: 19.26 to 19.34. Precipitated gold, 19.49.

Atomic weight: 196.2.

Revised atomic weight: 196.155.

Electric state: +.

Fusing point: 2016°.

Length of bar: 1.0015; (8th rank).

Wt. of cubic ft. in lbs.: 1208.6.

Tensile strength: 9.1.

Tenacity: 12; (6th rank).

Malleability: 1; (1st rank).

Ductility: 1; (1st rank).

Conducting power (heat): 2; (2d rank).

Conducting power (electricity): 779; (silver = 1,000). (3d rank).

Resistance to air, etc.: unaffected by air and by sulphuretted hydrogen.

Solubility: soluble in aqua regia, free chlorine or bromine, mercury; unaffected by action of single acids, alkalis, or sulphuretted hydrogen.

Direct combination: chlorine, bromine, phosphorus, antimony, arsenic, mercury.

Color and appearance: orange, yellow by reflected light, very brilliant, green by transmitted light. Lustre unaffected by high temperatures.

Consistence: soft. May be welded cold.

Compounds: auric and aurous.

Alloys: coinage, jewelry, etc., etc.

Structure: isometric crystals.

Value in dental amalgam alloys: [See Chapter VII.]

195. Occurrence: gold occurs native, that is, uncombined with other metals. It is found almost everywhere, but in most regions in exceedingly small quantities. It occurs in England, Scotland, Ireland, Wales, Hungary, Transylvania, Sweden, Spain, Italy, Siberia, in the Ural Mountains, Japan, Ceylon, Borneo, Thibet, Africa, Brazil, Chili, Peru, Mexico, California, and Australia. The greatest quantities are now found in Africa, California, and Australia. Gold is either in form of *alluvial gold*, that is, washed down by rivers, or *gold-quartz*, the metal being disseminated in thin plates and branch-like fragments, through lumps of quartz-rock.

196. Preparation: *alluvial gold* is extracted by washing the alluvial deposits, the separation of earthy matters being readily effected, owing to the high specific gravity of gold (19.3). In California and Australia a wooden trough, six feet long, resting on rockers and called a *cradle*, is used. At the head of it is a grating, on which the alluvial matter is thrown. A stream of water, entering the cradle, flows through and escapes at the lower end, leaving the gold in the trough, but carrying the earthy matters along with it. *Gold-quartz* must first be crushed, either by passing it through rollers, or by use of stampers. After pulverization, the gold is dissolved out by mercury. The amalgam resulting is then subjected to pressure, and excess of mercury thus squeezed out, the remainder being separated by distilling, leaving the gold.

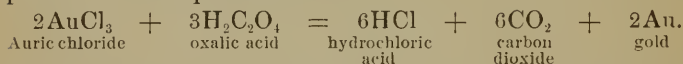
197. Refined gold may be obtained in various ways. Chlorine gas has been used as a refining agent, when gold is to be separated from silver. Nitric acid or sulphuric acid may be used. Sulphuric acid converts silver or copper into sulphates, and does not attack the gold.

American gold is liable to contain iridium, which may be separated from it by alloying the gold with silver, melting, and either pouring off the gold and silver alloy from the iridium, or treating with nitric acid and then with aqua regia.

198. **Chemically pure gold** is obtained from refined gold in various ways: for example, refined gold may be dissolved in aqua regia, excess of acid driven off by heat, then alcohol and potassium chloride added to precipitate any platinum present. The filtered solution is then evaporated over the water bath, the residue dissolved in distilled water, until each gallon contains not more than half an ounce of the chloride, the solution allowed to settle, the supernatant liquid syphoned off, and the gold precipitated in the metallic state by one of the various precipitants, such as oxalic acid or sulphurous anhydride.

199. **Agents used for Precipitating Gold:** gold may be precipitated in the metallic state by various substances.

*Oxalic acid* precipitates gold from its chloride solution in several forms, spongy or crystalline. Gentle heat favors the process. The equation is:



*Sulphurous acid* precipitates gold in scales, "not sufficiently coherent nor sponge like, for use as a filling material." (Essig).

*Ferrous sulphate* precipitates gold in form of a light-brown powder.

*Phosphorus* (as well as various other non-metals) when introduced into a heated solution of gold chloride, becomes coated with a film of metallic gold.

*Zinc* and other base metals precipitate gold as a brown powder.

*Metallic salts*, other than ferrous sulphate, and *organic acids*, other than oxalic, precipitate gold; the latter best from neutral solutions.

200. **Crystal gold** is obtained by reduction on a platinum pole by the electrical current. Plates of pure gold are suspended in a solution of auric chloride. These are connected with a battery, so that, as the solution loses its gold by deposition of the metal, it is re-supplied by the suspended plates (Essig).

201. **Pure Gold** may be **beaten** out so as to present a surface 650,000 times its original area. Dentists' leaf gold is usually

beaten from fine gold; a very small quantity of any other metal materially injures its malleability. To prepare leaf gold, the metal is first melted in a crucible with a little borax, poured into a mold to form an ingot  $\frac{3}{4}$  inch high, the ingot annealed and hammered with several annealings, until only  $\frac{1}{8}$  inch high, passed between rollers until reduced to a thin ribbon, cut into pieces an inch square; 150 of these pieces are piled up, alternately, with pieces of tough paper or vellum 4 inches square, rubbed over with a little fine plaster-of-Paris. Twenty vellums are then placed above, and twenty below the pile, which is firmly secured by passing two strong belts of parchment across it. The pile is placed on a heavy block of marble, and beaten with a hammer weighing about 16 pounds. After a time the middle leaves are shifted to the outside, and the beating continued, until the leaves are nearly the size of the vellums, when they are taken out and cut into 4 squares measuring an inch each way. They are then made into packets, with *gold-beaters' skins* in alternate layers, and beaten with a ten-pound hammer. When they are 4 inches square they are cut into 4 equal squares, again made into packets with gold-beaters' skin, and hammered again with a seven-pound hammer to about  $3\frac{1}{2}$  inches square. They are then lifted off the skin, cut down to one size, and packed between leaves of books. There are usually 25 leaves in a book, each of which is on an average  $\frac{1}{282,000}$  of an inch thick. They are now usually beaten by mechanical power. These leaves show, when held up to the light, a fine green color. Rendered non-lustrous by heat, the color is ruby-red. Weak solution of potassium cyanide slowly dissolves them. *Fine gold*, i. e., that which is perfectly free, is about as soft as lead. Its fineness is expressed by use of the term *carats*: gold coin containing 22 parts gold to 2 of alloy is said to be 22 carats fine; pure gold is 24 carats fine.

202. **Cohesive gold**, used for filling operations, may be obtained by heating foil to redness, by which the cohesiveness, which is greatly diminished by compression of the fibres in heating, is restored. "This is best effected by placing the foil upon a sheet of mica, which is held over a spirit-lamp." (Essig).

203. **Corrugated Gold**, according to Essig, is prepared by placing the sheets of gold between leaves of a particular kind of unsized paper, and tightly packing them in iron boxes, which are exposed to a temperature sufficiently high to carbonize the

paper. On cooling, the gold is found to be exceedingly soft and non-cohesive, and to present a peculiarly corrugated condition of surface. It can not be rendered cohesive by annealing.

Use in dentistry: gold is used by dentists in fine powder, and in foil for filling purposes. It is an ingredient of some amalgam alloys and of alloys for bases for artificial dentures, and in solders.

Gold containing palladium or platinum is *lighter* in color; if it contains copper, it is *redder* in color. Lead or antimony makes gold brittle, even if in minute proportion. Silver whitens the color of gold. Flagg thinks that from 5 to 7 per cent. will be proved the best proportionate quantity of gold in amalgam alloys.

#### 204. Compounds of Gold.—

**Auric Chloride** or the terchloride of gold,  $\text{AuCl}_3$ . Prepared by dissolving gold in aqua regia, using gentle heat. The solution evaporated to dryness over the water bath yields ruby-red, prismatic crystals, deliquescent, soluble in water, alcohol, ether, of disagreeable styptic taste; auric chloride stains the skin purple, but the stain is readily removed by potassium cyanide. It is an escharotic and disinfectant, and is used in dentistry, dissolved in ether, as an obtunding agent. Solutions should be kept in glass stoppered bottles, as the gold tends to deposit from solutions. It is a violent poison; administered to animals, death has resulted from its corrosive action.

**Aurous Oxide**,  $\text{Au}_2\text{O}$ , is a dark violet powder, formed by action of potassium hydrate on the corresponding chloride,  $\text{AuCl}$ .

**Auric Oxide**,  $\text{Au}_2\text{O}_3$ , is prepared from the terchloride by digesting magnesia in it, by which magnesium aurate is formed. The latter is decomposed by nitric acid, and the residue when dried is a dark brown, easily decomposing powder.

**Purple of Cassius** is a compound of gold, tin, and oxygen (see Chapter VII).

#### 205. Antimony.—

Symbol: Sb.

Latin name: Stibium.

Equivalence: III and V.

Specific gravity: 6.72.

Atomic weight: 120.

Revised atomic weight: 119.955.



Electrical state: —

Fusing point: 1150°F. [842°F. according to Am. authors.]

Length of bar: 1.0011; (11th in rank).

Weight of cubic feet in lbs.: 419.5.

Tensile strength: 0.5.

Tenacity:

Malleability: } (brittle).

Ductility: }

Conducting power (heat): 10; (10th rank).

Conducting power (electricity): 46 (silver = 1000); (11th rank).

Resistance to air, etc.: takes fire at red heat, but scarcely tarnishes in air.

Solubility: in boiling hydrochloric acid to which a little nitric has been added; in fine powder, dissolved by solutions of higher sulphides of Na and K.

Direct combinations: with chlorine, sulphur, oxygen, bromine, iodine.

Color and appearance: brilliant bluish-white, like zinc.

Structure: rhombohedral crystals like arsenic and red phosphorus; there is also an amorphous form.

Consistence: hard, brittle.

Compounds: antimonous (III) and antimonie (V).

Alloys: Britannia metal, pewter, type metal, Babbitt's anti-friction metal.

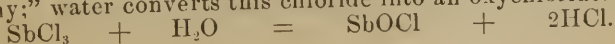
Value in dental amalgam alloys: said to make the amalgam "dirty."

Occurrence: antimony is found both native and combined. It occurs free in Germany. Gray antimony ore, the *sulphide*,  $\text{Sb}_2\text{S}_3$ , occurs in England, France, Hungary, and Borneo. An *oxide* is found in Algeria. *Red antimony*, which is a compound of the oxide and sulphide, is found in Tuscany.

Antimony is also found in the United States.

Preparation: the principal ore (stibnite), which is a sulphide, yields regulus of antimony (metallic antimony) when melted with metallic iron. A purer article is obtained by roasting the crushed ore, converting it into an oxide; the latter is then fused with charcoal.

Properties: the metal is not attacked by hydrochloric acid. Nitric acid converts it into a white, insoluble oxide. Aqua regia dissolves it, forming a chloride called "butter of antimony;" water converts this chloride into an oxychloride.





[The equation is given to illustrate the formation of an oxy-chloride].

206. Uses in dentistry and the arts: antimony is valuable as a constituent of alloys: to give hardness to other metals, and to cause them to expand and completely fill moulds on cooling.

It can be distinguished from other metals by its brittleness, crystalline structure, and hardness; it can easily be pulverized, and breaks from a slight tap of a hammer. It is not deemed a metal by some, being classed with arsenic, and phosphorus, rather than with the metals. It burns at red heat, with odor of garlic and with white fumes, suggesting arsenic. The amalgam with mercury is soft, and decomposed by contact with air or water, antimony separating. As a constituent of dental amalgam alloys, Flagg condemns it, on account of the "soiling", brought about in mixing and working.

207. **Bismuth.**—

Symbol: Bi.

Latin name: Bismuthum.

Equivalence: III and V.

Specific gravity: 9.78—9.80.

Atomic weight: 207.5.

Revised atomic weight: 207.5230.

Electrical state: +

Fusing point: 507°F.

Length of bar: 1.0014.

Wt. of cubic ft. in lbs.: 613.0.

Tensile strength: 1.5.

Tenacity:

Malleability: } Brittle.

Ductility: }

Conducting power (heat): 11; (11th rank).

Conducting power (electricity): 12; (12th rank).

Resistance to air: tarnishes in moist air.

Solubility: soluble in nitric acid; in hot sulphuric acid; in aqua regia.

Direct combinations:

Color and appearance: white with bronze tint; highly crystalline appearance.

Structure: crystallizes in rhombohedrons.

Consistence: hard, brittle.

Compounds: bismuthous and bismuthic.

Alloys: fusible metal, pewter, pewterer's solder.

Value in dentistry: for making readily fusible alloys.

Occurrence: this metal occurs native, disseminated through rocks in veins. It is rather rare, and is found associated with ores of nickel, cobalt, silver, and copper. Saxony and Bohemia are the chief sources, but it is also found in Transylvania, England, United States, Sweden, Norway, and Peru.

Preparation: to extract the metal, the earthy matters containing it are heated, and the melted bismuth is collected in suitable receivers.

208. Use in dentistry: the value of bismuth in alloys is due to its low melting point, and to the fact that it *expands* very considerably as it solidifies. Compressed bismuth is lighter than that which has not been so treated. It is more easily vaporized than many metals, and boils at moderate white heat. It tends to crystallize from fusion in a remarkable manner, in rhombohedrons of great size and beauty, often mistaken for cubes.

An alloy of tin, lead and bismuth, is employed for testing the finish of a die. Bismuth is used in the dental laboratory for making readily fusible alloys for dies, and counter-dies. It lowers the fusing point and imparts hardness, when used in alloys.

#### 209 Compounds of bismuth.—

**Bismuth subnitrate:** official name, Bismuthi Subnitrates. Formula,  $\text{BiONO}_3 \cdot \text{H}_2\text{O}$ . Molecular weight, 303.5. It is, as will be seen from the formula, the nitrate of the oxide of bismuth. It is called *bismuthyl* nitrate by some authors, also bismuth trisnitrate and oxynitrate. Recent investigators deem it not a fixed and definite compound, but rather a mixture. The chemistry of its preparation is complicated: bismuth is first dissolved in nitric acid, forming the nitrate; next, bismuth subcarbonate is made from the nitrate, by the action of sodium carbonate; the bismuth subcarbonate is next redissolved in nitric acid, to form bismuth nitrate again; finally, the bismuth nitrate is converted into subnitrate by action of ammonia water. Good subnitrate of bismuth is soft, bulky, insoluble in water, soluble in nitric acid. It often contains arsenic as impurity. Treatment in poisoning, as for arsenic. Used in dentistry, internally and topically.

#### 210. Tin.—

Symbol: Sn.

Latin name: Stannum.

Equivalence: II and IV.

Specific gravity: 7.29 to 7.30.

Atomic weight: 118.

Revised weight: 117.698.

Electrical state: +

Fusing point:  $442^{\circ}\text{F}$ . (According to some,  $458.6^{\circ}\text{F}$ ).

Length of bar at  $212^{\circ}$ : 1.0023; (4th rank).

Weight of cubic feet in lbs: 455.1.

Tensile strength: 2 to 3.5.

Tenacity: 1.33 compared with lead; (9th rank).

Malleability: 4; (4th rank).

Ductility: 9; (9th rank).

Conducting power: (heat) 7; (7th rank).

Conducting power: (electricity) 83, (silver=1000); (9th rank).

Resistance to air, etc.: 3; (3d rank).

Solubility: soluble in dilute acids and alkalis. Resists corrosion of air, water, etc., better than iron or copper. Nitric acid converts it into metastannic acid. Dissolved in hydrochloric acid, stannous chloride is formed. In aqua regia, stannic chloride.

Direct combinations: with oxygen when strongly heated, sulphur, chlorine. It does not combine chemically with mercury.

Color and appearance: white, brilliant.

Structure: crystalline in two systems, isometric and quadratic.

Consistence: soft.

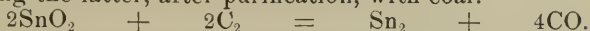
Compounds: stannic (equivalence IV), and stannous (equivalence II).

Alloys: pewter, britannia, queen's metal, solder, bell-metal, gun metal, bronze, speculum metal, fusible metals, sterro-metal, type metal.

Value in dental amalgam alloys: 2.

Occurrence: tin occurs chiefly in form of *tinestone*, stannic oxide,  $\text{SnO}_2$ . The ore is found in Cornwall, Australia, Bohemia, Saxony, Malacca, Banca, Siberia, Sweden, North and South America. Tin obtained from Malacca and Banca is known as *straits tin*, and is of great purity. The tin deposits of New South Wales cover an area of over 5,000,000 acres; tin ore is also very abundant in Queensland. In the United States, tin ore has been found in West Virginia, and adjoining parts of Ohio, in North Carolina, and in the far West, as in Utah.

Preparation: the metal is easily obtained from the ore by heating the latter, after purification, with coal:



211. *Pure tin*, in crystalline form, may be thrown down by introducing a plate of tin into a strong solution of stannous chloride, on which water is floated. Another method by which tin, entirely pure, may be obtained is, by evaporating a solution of stannous chloride to small bulk, and oxidizing by addition of nitric acid. Stannic oxide is obtained, which, after washing and drying, is exposed to red heat in a crucible with charcoal.

212. Tin in dentistry: tin amalgamates readily with mercury, and in most cases there is condensation. [Flagg puts tin second, in the list of metals soluble in dental amalgam alloys, the "shrinkage" being counterbalanced by addition of copper and gold. All alloys which he regards with favor contain from 35 to 48 per cent of tin]. Pure tin in form of foil is used as a filling, and also in connection with non-cohesive gold.

### 213. Compounds of Tin.—

#### Stannous Chloride:

This substance, known to the dyer as "tin salt," is made by dissolving metallic tin in hydrochloric acid. It may be prepared by distilling tin filings with mercurous chloride. Its formula is  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ ; molecular weight, 224.5. It is used locally. It is poisonous; the antidotes are baking soda, magnesia, milk, and white of egg. Tin dissolved in nitrohydrochloric acids yields stannic chloride,  $\text{SnCl}_4$ . The two chlorides of tin in connection with auric chloride yield purple of Cassius.

### 214. Platinum.—

Symbol: Pt.

Latin name: Platinum.

Equivalence: II. and IV.

Specific gravity: 21.50. Heaviest substance in nature.

Atomic weight: 197.

Revised atomic weight: 196.700; (according to some, 194.8).

Electrical state: +.

Fusing point: above  $3500^\circ$  in oxyhydrogen flame, or coal-gas and oxygen flame.

Length of bar, etc.: 1.0009; (13th rank, least expansible of the 13 metals).

Wt. cubic ft. in lbs.: 1,344.

Tensile strength:

Tenacity: 15, compared with lead; (4th rank).

Malleability: 5; (5th rank).

Ductility: 3; (3d rank).

Conducting power; heat: 8; (8th rank).

Conducting power; electricity: 180 (silver = 1,000); (6th rank).

Resistance to air, etc.: 1; (1st rank).

Solubility: dissolves slowly in aqua regia. Acted on by fused alkaline hydrates at red heat.

Direct combinations: sulphur, phosphorus, arsenic, silicon, chlorine.

Color and appearance: white with tinge of blue, brilliant, but less than silver.

Structure: (native) rounded grains; sometimes octahedral crystals.

Consistence: hard as copper.

Compounds: platinous (II), and platinic (IV).

Alloys: with most metals. Gold, silver, lead, form easily fusible alloys with it.

Value in dental amalgam alloys: disputed.

215. **Platinum Metals:** These are platinum, rhodium, palladium, ruthenium, and iridium.

Occurrence: the chief supply of platinum, which, like gold, is found free, is derived from the Ural Mountains. The Russian platinum diggings are near Bogoslawsk, Miask, Newjansk, and Nischnei Tagilsk. It is also found in Brazil, Peru, Columbia, California, and Borneo. The Russian platinum is always associated with other metals: analysis showed in one specimen, 75.1 platinum, 1.1 palladium, 3.5 rhodium, 2.6 iridium, 0.6 osmiridium, 2.3 osmium, 0.4 gold, 1.0 copper, and 8.1 iron.

Preparation: the platinum is dissolved in fused galena, a little glass is introduced to melt over the surface, and a quantity of litharge, equal in weight to the galena, is gradually added. Sulphurous acid gas, from the lead sulphide and lead oxide, is formed, leaving metallic lead in combination with the platinum, free from osmium and iridium. The lead-platinum combination is then treated in a *cupellation* furnace, that is, a furnace containing a *cup*, made of bone ash, the lead removed as an oxide, leaving the platinum in spongy state on the cupel. The spongy platinum is refined in a lime furnace, by the heat of an oxy-hydrogen, or coal-gas and oxygen flame.

216. Use in dentistry: metallic platinum does not amal-

gamate with mercury, but spongy platinum unites when triturated with mercury in a warm mortar, or in contact with acetic acid.

The value of platinum in amalgam alloys is disputed; combined with tin, silver, and gold, it is said to be valuable in that it gives such alloys greater "hardness," and quicker "setting" properties; [but Flagg objects to "hardness," and claims that "quick setting" can be brought about without use of platinum]. An alloy of silver, with one-third its weight of platinum is used in dentistry, on account of its great elasticity. Platinum alloyed with iridium has been used in the manufacture of dental "plates;" great strength is characteristic of this alloy.

217. **Palladium.**—

Symbol: Pd.

Latin name: Palladium.

Equivalence: II and IV.

Specific gravity: 11.80.

Atomic weight: 106.

Revised atomic weight: 105.737.

Electrical state: +

Fusing point: lower than platinum, but requires oxy-hydrogen blow-pipe.

Length of bar, etc.: 1.0010; (12th in rank)

Wt. of cubic ft. in lbs.: 736.6.

Tensile strength:

Tenacity:  $11\frac{1}{2}$  (Lead = 1); (7th rank).

Malleability: inferior to platinum.

Ductility: 6; (6th rank).

Conducting power (heat):

Conducting power: (electricity): 184 (silver = 1000); (5th rank).

Resistance to air, etc.: 1; first rank. More oxidizable than platinum at red heat.

Solubility: soluble in nitric acid; attacked by iodine; aqua regia best solvent.

Direct combinations: cyanogen, iodine.

Color and appearance: like platinum or a platinum-gold alloy.

Structure: native, grains of fibrous appearance.

Consistence:

Compounds:

Alloys: salmon-bronze.

Value in dental amalgam alloys: high price of the metal and difficulty of procuring it are the chief objections to its use: palladium amalgam "sets" very rapidly.

218. Use in dentistry: palladium is harder than platinum, but only half as heavy. Its amalgam sets so rapidly that, unless made very soft, it can not be properly inserted as a filling. (Flagg.) It is extracted from its ores, etc., by a chemical process, and is very expensive. It was formerly obtained in tolerable abundance in Brazil, but the supply has failed of late. "Dental alloys in which palladium is a constituent, blacken to a greater extent than when it is omitted." (Essig.)

219. Iridium.—

Symbol: Ir.

Latin name: Iridium.

Equivalence: II, IV, VI.

Specific gravity: 21.1.

Atomic weight: 197.

Revised atomic weight:

Electrical state: +

Fusing point: fusible in oxyhydrogen blow-pipe.

Length of bar, etc.:

Wt. of cubic foot in lbs.:

Tensile strength:

Tenacity:

Malleability: somewhat malleable at red heat.

Ductility:

Conducting power (heat):

Conducting power (electricity):

Resistance to air: unalterable in air.

Solubility: not soluble in aqua regia unless alloyed with platinum.

Direct combinations: sulphur, chlorine, iodine, oxygen.

Color and appearance: white, like polished steel.

Structure:

Consistence: very hard. Brittle.

Compounds: iridic, iridious, hypoiridious.

Alloys: with platinum.

Value in dentistry: for alloy with platinum in manufacture of plates.

220. Aluminum.—

Symbol: Al.

Latin name: Aluminum or Aluminium.



Equivalence: IV and  $(Al_2)^{VI}$ .

Specific gravity: 2.50 to 2.67.

Atomic weight: 27.

Revised atomic weight: 27.009.

Electrical state: +

Fusing point:  $1292^{\circ}F$ .

Length of bar, etc.: 1.0022; (5th rank).

Wt. of cubic ft. in lbs.: 166.8.

Tensile strength: 12.

Tenacity:

Malleability: like silver and gold.

Ductility: 7; (7th rank).

Conducting power (heat): 4; (4th rank).

Conducting power (electricity): better than that of iron.

Resistance to air, etc.; tarnishes very slowly; not affected by sulphureted hydrogen.

Solubility: soluble in hydrochloric acid, and in aqueous solutions of alkaline hydrates; resists cold acids, mineral and vegetable (except hydrochloric).

Direct combinations: with many metals and non-metals. Does not oxidize and is not attacked by sulphur compounds.

Color and appearance: bluish white, brilliant.

Structure: octahedral crystals.

Consistence: hard as zinc. Very sonorous.

Compounds: two atoms with hexad equivalence like ferric salts.

Alloys: aluminium bronze, solder, etc. Does not amalgamate.

Value in dentistry: for making "plates."

Occurrence: the great mass of the earth is composed of aluminum, in combination with silicic acid, in silicated rocks such as granite, feldspar, basalt, slate, mica, etc., and in the various modifications of clay. Every variety of clay contains it, in quantity varying from 12 to 20 per cent. The minerals known as corundum, ruby, sapphire, and emery are *aluminium oxide* in crystallized state.

Preparation: the usual process for obtaining aluminum has been to decompose the chloride by metallic sodium:



It will be noticed that aluminum acts as a pseudo-triad,  $(Al_2)^{VI}$ , in the chloride of aluminum.

The process is that of Deville. At the works of Morin in

Paris, ten parts sodio-aluminum chloride, five parts of fluor-spar or cryolite, and two parts of sodium, are mixed together and thrown upon the hearth of a reverberatory furnace, previously heated to full redness. A violent action takes place, great heat is evolved, and the liquefied mass of slag and metal collects at the back of the furnace. The latter is drawn off and cast into ingots.

Metallic sodium is very troublesome to handle, and its cost is so high that the price of aluminum has been, in consequence of the difficulty and expense of the process, higher per troy ounce than that of silver. Recent improvements in process have been made in this country: one is to reduce the aluminous materials with sodium vapor, and to use the double fluoride of aluminum and sodium, or double chloride of aluminum and sodium, made at reduced cost; another is to prepare the metal electrolytically; another to reduce the aluminous earths with zinc ore. The price will probably be greatly reduced before long. Metallic magnesium has been reduced to one-fifth of its previous price, and, as this substance also is used in manufacture of aluminum it will probably affect the price of the latter.

221. Value in dentistry and in the arts: aluminum is remarkable for its resistance to the air, and for its great lightness. It is said to be stronger than steel. It is four times lighter than silver, and seven or eight times lighter than platinum. Gas fumes and sulphur do not tarnish it. It is whiter than nickel, and makes a fine substitute for silver. Alloyed with silver and copper, it gives a non-tarnishing and non-corrosive quality to these metals, and greatly increases their tensile strength. Aluminum bronze is 10 pounds of aluminum to 90 pounds of copper, and has a tensile strength of three tons per square inch greater than Bessemer steel. A solder has been invented which, it is claimed, will enable aluminum to be welded. [An alloy of aluminum and tin has been used, 10 parts tin to 100 of aluminum, for internal parts of instruments, as electrical instruments. The apex of the Washington Monument is of aluminum; its surface appears much whiter than silver, and is so highly polished as to resemble a plate glass mirror].

In prosthetic dentistry the use of aluminum has been urged, on the ground (1) that it is the only metal which can be used *pure* and unalloyed in the manufacture of plates, (2) that it is the lightest of the metals available for such a purpose. It is

claimed by some that aluminum is unalterable in the mouth and does not irritate the gums, hence is superior to caoutchouc. It is thought therefore, that it will replace gold and platinum in prosthetic dentistry. Others claim that it is gradually attacked by articles used in diet, such as vinegar and solutions of common salt. According to Palmer, there is little or no galvanic action in the oral cavity when aluminum is used; a carpet tack may be held in the mouth, in contact with the aluminum, without unpleasant sensation.

Essig thinks that "the readiness with which it is attacked by alkaline solutions renders it unfit for use in the construction of a permanent artificial denture."

## 222. Compounds of Aluminium.—

### Alums:

Theoretical constitution: alums are what are known as "double salts". They are formed by the combination of aluminium sulphate with other sulphates. The formula for aluminium sulphate is  $(Al_2)_2(SO_4)_6$  or  $Al_2(SO_4)_3$ , aluminium being a pseudo-triad. The formula for potassium sulphate is  $K_2SO_4$ , for ammonium sulphate  $(NH_4)_2SO_4$ . The formula for potash alum or potassium *and* aluminium sulphate is  $K_2Al_2(SO_4)_4$ , that is  $K_2(SO_4) + Al_2(SO_4)_3$ . Ammonia alum is  $(NH_4)_2Al_2(SO_4)_4 \cdot 24H_2O$ . *Ferric* alum contains no aluminium at all, but is the double sulphate of ammonium and ferric iron, thus  $(NH_4)_2Fe_2(SO_4)_4 \cdot 24H_2O$ . The official alum is potash-alum,  $K_2Al_2(SO_4)_4 \cdot 24H_2O$ .

Official name: *Aluminii et Potassii Sulphas*.

Preparation and properties: alum is manufactured, on a large scale, by decomposing various silicates of aluminium with sulphuric acid, aluminium sulphate being formed. To this is added solution of potassium sulphate, if potash alum be desired, or ammonium sulphate, if ammonia alum is sought. On evaporation, the alum crystallizes.

Potash alum occurs in form of regular octohedral crystals, white, efflorescent, soluble in 10 parts cold water, and 0.3 parts boiling, insoluble in alcohol; its solution has an acid reaction, and an astringent, sweetish, taste. By heating for several days at a temperature of  $176^\circ F.$ , the water of crystallization is expelled, and it becomes dried alum, *Alumen exsiccatum*. Alum is used in dentistry as an astringent and styptic, and, in connection with Labarraque's solution, as a bleaching agent. Its solutions are acid, hence habitual use of them may prove injurious to the teeth. Alum is used, in prosthetic dentistry, to harden plaster casts.

**Aluminium chloride:** this substance,  $\text{Al}_2\text{Cl}_6$ , comes in colorless, deliquescent crystals, very soluble in water, of a sharp saline taste, antiseptic, disinfectant. It is made by passing chlorine gas over a mixture of charcoal and alumina at bright red heat:



It has been used to bleach discolored teeth.

The substance called *Chloralum* contains the chloride of aluminium.

**Aluminium permanganate:** this substance is said to be a constituent of some disinfecting solutions.

**Aluminium silicates:** there are many silicates of aluminium. Clay is a hydrated silicate, usually mixed with excess of silica. Purer kinds of clay are derived from feldspar of the formula,  $\text{Al}_2\text{O}_3, \text{K}_2\text{O}, 6\text{SiO}_2$ . On exposure to air, the silicate of aluminum alone remains, the alkaline silicates washing away. Earthenware, bricks, and pottery are made from clay, porcelain and the better kinds of stoneware from purest clay, and glazed with feldspar. Firebrick, crucibles, and the like are prepared from pure varieties of clay, free from lime, magnesia, or iron, but containing a large proportion of silica. Common clays have the formula  $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ ; some kinds of fire clay,  $\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ . Silicate of aluminum is an ingredient of hydraulic cement.

**Alumina** is an oxide,  $\text{Al}_2\text{O}_3$ . Corundum and emery are nearly pure alumina.

223. **Iron.**—

Symbol: Fe.

Latin name: Ferrum.

Equivalence: II.

Specific gravity: 7.79—7.84.

Atomic weight: 56.

Revised atomic weight: 55.9130.

Electrical state: +

Fusing point:  $3500^\circ\text{F}$  (wrought iron). Ordinary,  $2900^\circ\text{F}$ .

Length of bar: 1.0012 (10th rank).

Weight of cubic foot in lbs: 489.4.

Tensile strength: 29.0 (maximum).

Tenacity:  $27\frac{1}{2}$ , steel 42, (1st rank).

Malleability: 8; (8th rank).

Ductility: 4; (4th rank).

Conducting power (heat): 6; (6th rank).

Conducting power (electricity): 168; (silver = 1000); (7th rank).

Resistance to air: rusts in moist air.

Solubility: soluble in hydrochloric and sulphuric acids; in dilute nitric.

Direct combinations: chlorine, bromine, iodine, sulphur, and members of the phosphorus group except nitrogen.

Color and appearance: depend on variety. Pure iron is white.

Structure: white cast-iron, crystalline; gray-iron, granular, wrought iron, fibrous, crystals probably cubical.

Consistence: pure iron is soft and tough.

Compounds: ferric ( $\text{Fe}_2$ )<sup>VI</sup>, ferrous, and ferroso-ferric.

Alloys: Aich's metal, arguzoid. German silver plate, ferro-metal.

Value in dentistry: as steel, and in many ways.

Occurrence: the iron ores are very numerous and widely distributed; those used in the manufacture of iron are hæmatite ( $\text{Fe}_2\text{O}_3$ ), magnetite ( $\text{Fe}_3\text{O}_4$ ), limonite (a hydrate), and siderite ( $\text{FeCO}_3$ ).

Preparation: the general process is to reduce with carbon, metallic iron and the oxides of carbon being formed. Sometimes the ore is first roasted to get rid of sulphur, carbonic acid, water, etc. The ore, containing iron oxide, is then reduced, *i. e.* deprived of its oxygen, in a blast furnace, which is filled at the top with alternate layers of coal, broken ore, and fluxes, such as limestone or silicates. Iron obtained by this method is known as **cast-iron**, and contains more or less carbon and slag, when drawn off into moulds to form **pig-iron**. **Wrought-iron** is made by subjecting pig-iron to the **puddling process**, during which the molten metal is thoroughly stirred in reverberating furnaces, where there is a free supply of air, so that the carbon of the pig-iron is burned, and other impurities oxidized.

224. *Steel* is now made by the Bessemer process, by blowing air under great pressure into molten cast-iron, consuming the carbon; iron rich in carbon and manganese, termed *spiegel eisen*, is then added to give the proper amount of carbon.

*Malleable iron* is steel which has undergone further treatment by heat and atmospheric air.

225. Dental uses of iron: iron is by far the strongest and yet one of the lightest of the metals; steel is the strongest and

one of the hardest and most elastic of all materials; malleable iron possesses great strength and toughness, but is soft enough to be turned, bored and punched, and, when heated, is easily wrought and without cracking. Wrought-iron, at bright red heat, can be welded, that is, joined to another piece of metal, without use of solder. Wrought-iron has the property of acquiring, with great rapidity, the properties of a magnet and of parting with them rapidly, hence is well adapted for use in the construction of electro-magnetic and magneto-electric apparatus. Cast iron is easily melted and can be made into castings, which may be readily filed or turned, or so hard that no tool can affect them.

When cold, iron is the least malleable of metals in common use, but when heated, its ductility is such that it can be rolled into the thinnest sheets, and drawn into the finest wire, which, when  $\frac{1}{10}$  inch in diameter, will sustain a weight of 700 pounds. With exception of platinum, iron is the least fusible of the useful metals.

226. **Compounds of Iron:** compounds of **Iron** are of two kinds, ferric and ferrous:

**Ferric compounds:** iron as a pseudo-triad. *Ferric chloride*,  $\text{Fe}_2\text{Cl}_6$ , per-chloride, sesquichloride, chloride of iron, *Ferri Chloridum*; orange-yellow, deliquescent, soluble. *Liquor ferri chloridi*, U. S. P., contains 37.8 per cent, of the anhydrous. "Tincture of Iron" is one part of the *Liquor* to about two of alcohol (*Tinctura Ferri Chloridi*, U. S. P.); hemostatic, strong chalybeate, styptic taste, acid reaction, stains teeth and acts on them. *Ferric Hydrate*,  $\text{Fe}_2(\text{HO})_6$ , hydrated oxide, hydrated peroxide, peroxide, sesquioxide, red oxide. Precipitate ferric sulphate or ferric chloride by ammonia or by sodium hydrate. Reddish-brown powder used as antidote to arsenic; must be freshly made. *Hydrated oxide of iron with magnesia*, U. S. P., made by adding magnesia to a solution of ferric sulphate. *Ferric Sulphate*,  $\text{Fe}_2(\text{SO}_4)_3$ , in solution forming "solution of tersulphate of iron," U. S. P., color reddish-brown. *Ferric Subsulphate* (doubtful composition),  $\text{Fe}_4\text{O}(\text{SO}_4)_5$ , called "Monsel's solution," ruby-red; valuable as a hemostatic, may be taken internally. *Dialyzed Iron*, aqueous solution of about 5 per cent of ferric hydrate with some ferric chloride. Ammonia is used in making it, and the ammonium chloride formed passed through a dialyzer.

**Ferrous compounds:** iron as a dyad. Ferrous salts are usually green, and alter in the air to *ic* salts. *Ferrous chloride*,



$\text{FeCl}_2$ , protochloride; *ferrous iodide*,  $\text{FeI}_2$ , protiodide, green, volatile, deliquescent, soluble. *Ferrous sulphide*,  $\text{FeS}$ , proto-sulphide, sulphuret of iron, is used to make  $\text{H}_2\text{S}$  (sulphuretted hydrogen). *Ferrous sulphate*,  $\text{FeSO}_4$ , green vitriol, copperas; dissolve iron in  $1\frac{1}{2}$  parts  $\text{H}_2\text{SO}_4$  diluted with 4 parts water; efflorescent, bluish-green crystals, acrid, styptic taste, soluble in water, insoluble in alcohol, astringent, irritant, disinfectant.

227. Dental uses of compounds of iron: ferric chloride is used externally to arrest alveolar hæmorrhage, either in form of the delinquesced crystals or in solution. It is also applied to fungous tumors. It is given internally. Monsel's powder and solution are used to arrest hæmorrhages following extraction of teeth, etc., etc.

#### 228. Nickel.—

Symbol: Ni.

Latin name: Niccolum.

Equivalence: II, IV,  $(\text{Ni}_2)^{\text{VI}}$ .

Specific gravity: 8.60 to 8.82.

Atomic weight: 58.

Revised atomic weight: 57.928.

Electrical state: +

Fusing point: less than iron.

Length of bar:

Weight of cubic foot in lbs.: 541.2.

Tensile strength: same as iron.

Tenacity: like iron, very great.

Malleability:

Ductility:

Conducting power (heat):

Conducting power (electricity): 131; (8th rank).

Resistance to air: rusts less readily than iron; tarnishes in moist air.

Solubility: soluble in dilute mineral acids, especially nitric.

Direct combinations: with chlorine, cyanogen, sulphur, oxygen.

Color and appearance: silver-white, with a slight yellowish tinge and very lustrous; magnetic.

Structure:

Consistence: hard.

Compounds: mostly nickelous.

Alloys: arguzoid, electrum, German silver, tutenag.

#### 229. Cobalt.

Symbol: Co.

Latin name: Cobaltum.



Equivalence: II, IV, and  $(\text{Co}_2)^{\text{vi}}$ .

Specific gravity: 8.49 to 8.9.

Atomic weight: 59.

Revised atomic weight: 58.8870.

Electrical state: +

Fusing point: less than that of iron.

Length of bar:

Weight of cubic foot in lbs.: 558.7.

Tensile strength: like iron.

Tenacity: like iron.

Malleability: like iron.

Ductility: like iron.

Conducting power (heat):

Conducting power (electricity):

Resistance to air: like nickel.

Solubility: like nickel.

Direct combinations: chlorine, oxygen, sulphur.

Color and appearance: reddish-white. Magnetic.

Structure: has granular fracture.

Consistence: hard.

Compounds: cobaltous, cobaltic, and cobaltous-cobaltic like ferroso-ferric.

Alloys:

Value in dentistry:

**Nickel and Cobalt:**

Occurrence: the nickel ores are arsenide,  $\text{NiAs}$ , and silicate.

Silicate of nickel is found in New Caledonia. Kupfernickel, the arsenide, occurs in Germany, Hungary, Norway, and Bolivia. Cobalt ores are the same as nickel, except the silicate.

Preparation: the arsenides are roasted, treated with hydrochloric acid, and the nickel thrown down by potassium hydrate. The process is a complicated one, and includes many particulars here omitted.

230. Uses: cobalt is higher priced than nickel. Nickel is chiefly used for plating, and as an alloy in coins, instruments, etc., and as a whitening agent.

## CHAPTER VII.

### ALLOYS, AMALGAMS, AND CEMENTS.

231. **General Properties of Alloys:** alloy is the name given to a combination obtained by fusing metals together. They are, as a rule, chemical compounds, dissolved in excess of one of the constituent metals, but many are merely mechanical mixtures, or *molecular mixtures*, as the term is. All alloys exhibit the metallic nature in their physical characteristics. As regards **specific gravity**, an alloy of gold and silver is lighter than the theoretical mean of its constituents; brass, and an alloy of lead and tin, heavier; in other words the gold and silver alloy is formed by expansion, the latter by contraction. In the formation of some alloys there is no change in volume. In **color**, alloys are usually **gray**, unless there is sufficient copper or gold to impart the characteristic color of those metals. Alloys are usually **harder**, and **more brittle**, **less ductile**, and **less tenacious**, than the constituent metal exhibiting these qualities in the highest degree; aluminum bronze is an exception, its tenacity being greater than that of either of the constituent metals.

232. The **fusibility** of an alloy is generally greater, *i. e.*, the alloy melts more readily, than that of the least fusible constituent metal, and sometimes than that of any constituent metal. An alloy **heated gradually** to near its fusing point undergoes a change: its constituents reunite to form a mass now fusible; if the fluid be poured off, a solid alloy is obtained less fusible than the original. In this way copper is separated from silver. An alloy of zinc or of mercury is **decomposed** by heat, but at a higher temperature than the point of ebullition of the metal. As regards *temperature*, an alloy of 94 copper to 6 tin, if *slowly* cooled, becomes brittle but, if cooled

*rapidly* with cold water, malleable. Mercury, bismuth, tin and cadmium give fusibility to alloys, tin hardness and tenacity, lead and iron hardness, antimony and arsenic brittleness. Metals are usually **fused** under a layer of charcoal to prevent oxidation; they are mixed by agitation, and allowed to cool slowly.

233. Certain peculiarities of alloys as to **solubility** must be noticed: platinum is insoluble in nitric acid, but an alloy of platinum with silver is soluble in the acid. Silver is readily soluble in nitric acid, but an alloy of silver, with 25 per cent. gold, is insoluble.

234. The **affinity** of an alloy for **oxygen** is greater than that of the separate metals, but the action of **air** is in general less on alloys, than on the separate metals composing them, with some exceptions.

235. Some difficulty is occasionally experienced in obtaining a **perfectly uniform alloy**, on account of the different specific gravities of the metals composing it—each metal assuming the level due to its specific gravity. This result is not so likely to occur, when the metals employed are in small quantities, briskly stirred, and suddenly cooled. In alloying three or more metals differing greatly in fusibility, or that have but little affinity for one another, it is better to unite first those that most readily combine, and then this combination with the remaining metal or metals. If, for example, it is desired to unite a small quantity of lead with brass or bronze, some difficulty would be experienced in forming the alloy by direct incorporation of the metals, but union could be readily effected by first melting the lead with zinc or tin, and then adding the melted copper. (Richardson).

236. **Alloys consisting of two metals**, one readily oxidizable, the other possessing less affinity for oxygen, **may be readily decomposed** by the combined action of heat and air." (Essig).

TABLE 20.—EFFECT ON GOLD OF ALLOYING.

Malleability: impaired; seriously by As, Sn, Sb, Bi, Pb.

Ductility: diminished.

Hardness; increased.

Tenacity: usually increased.

Specific gravity: varies; with Zn, Sn, Bi, Sb, Co, sp. gr. greater than mean of components; with Ag, Fe, Pb, Cu, Ir, Ni, less than the mean.

Fusibility: usually increased.

TABLE 21—SPECIFIC EFFECTS OF CERTAIN METALS ON GOLD WHEN ALLOYED WITH IT.

METAL.	EFFECT.
Zinc:	forms hard, white, brittle alloy (when in equal proportions); does not unite so intimately as lead or tin, and does not destroy ductility.
Tin:	renders gold intractable to remarkable degree. The combination is attended with contraction.
Lead:	renders gold intractable.
Antimony:	renders gold intractable. One part in 1920 too brittle for successful lamination.
Bismuth:	renders gold intractable in almost inappreciable quantities, as 1 in 1920.
Iron:	does not sensibly affect malleability, in the proportion of 1 to 11.
Mercury:	dissolves gold, and combines with it at all temperatures, but more readily when gold is in state of fine division, and when heat is applied.
Arsenic:	malleability of gold affected, even by vapor of arsenic. The color of the gold may not be changed, even when it has become brittle.
Silver:	renders gold more fusible, increases hardness, does not materially affect malleability, makes color lighter.
Palladium:	equal parts: gray color, less ductile. 4 gold, 1 palladium: white, hard, ductile. Merest traces of palladium render gold brittle.
Copper:	hardens and toughens gold, gives deeper color, renders it capable of receiving rich polish, does not practically impair its malleability.
Platinum:	in small proportions hardens, and renders more elastic, without impairing malleability. Makes color pale and dull, if equal weights. Excess of platinum renders alloy infusible in blast furnace.

TABLE 22—APPEARANCE OF GOLD ALLOYS.

ALLOY METAL.	COLOR, ETC.
Tin.	Light colored, very brittle.
Lead.	Dull colored, brittle.
Platinum.	Grayish or dull colored, malleable, tough, elastic.
Zinc.	Unequally malleable, brittle in spots.

## 238. Composition of Alloys.—

**Babbitt metal** is an alloy of copper, 3 parts; antimony, 1 part; tin, 3 parts. The copper is fused and then antimony and tin are added to it. It melts at a moderately low heat; contracts but little; is brittle, but may be rendered less so by adding tin. (Richardson).

239. **Brass** is an alloy of copper and zinc. Common brass is 66.6 copper, and 33.3 zinc; best brass, 71.4 copper to 28.6 zinc. Yellow brass is 60 copper to 40 zinc. Brass melts at 1869°F.

240. **Bell metal** is an alloy of 6 parts copper, to 2 parts tin; some varieties are 78 copper to 22 tin. *Cannon metal* is 90 copper, to 10 of tin.

241. **Bronze** is an alloy of copper and tin. **Aluminum bronze**, 900 parts copper to 100 of aluminium. The latter has been used for the under layer of teeth plates, and is said to be free from injurious oxidation, and to be more easily manipulated than gold alloys or silver. It may be stamped and pressed, almost as easily as pure silver, while possessing the elasticity of steel. Its melting point is higher than that of pure gold, so that it may be made red-hot without danger of melting and can be manipulated with hard solder. Sauer solders it with from 14 to 16 carat red gold. Aluminum bronze is one-half lighter than 12 carat silver and almost half the weight of 14 carat gold. It oxidizes, only superficially, in the mouth; it is affected, superficially, by a 1 in 1000 solution of corrosive sublimate, but not by carbolic acid.

242. **Gold aluminum bronze** oxidizes more readily, is softer, and not so elastic.

243. **Fusible alloys** are of different compositions, but contain *bismuth*. One is bismuth 2 parts, lead 1 part, tin 1 part; melts at 200°F. Another is 50 bismuth, 12.5 cadmium, 25 lead, 12.5 tin.

TABLE 23—FUSIBLE ALLOYS.

METALS.	Melting Point.	Contrac- tivity.	Hard- ness.	Brittle- ness.
1. Zinc.	770°F	.01366	.018	5
2. Lead, 2, Tin, 1.	440	.00633	.050	3
3. Lead, 1, Tin, 2.	340	.00540	.040	3
4. Lead, 2, Tin, 3, Antimony, 1.	420	.00433	.026	7
5. Lead, 5, Tin, 6, Antimony, 1.	320	.00566	.035	6
6. Lead, 5, Tin, 6, Antimony, 1, Bismuth, 1.	300	.00266	.030	9
7. Lead, 1, Tin, 1, Bismuth, 1.	250	.00066	.042	7
8. Lead, 5, Tin, 3, Bismuth, 8.	200	.00200	.045	8
9. Lead, 2, Tin, 1, Bismuth, 3.	200	.00133	.048	7

Under the head of brittleness those marked below 5 are malleable, those above 5, brittle. Zinc is either malleable or brittle according as it is managed. (Austen).

244. **Gold Alloys and Alloys Resembling Gold:** gold coinage: gold 90, copper 10. Gold jewelry and plate: gold 75 to 92, copper 25 to 8.

*Green gold:* gold 75, silver 25.

*Red gold:* gold 75, copper 25.

*Dutch gold* is merely a species of brass, usually sold in very thin leaves or sheets. It is formed of 11 parts copper with 2 of zinc.

*Fool's gold* is iron pyrites, a sulphide of iron.

*Oreide* is a species of brass.

*Pinchbeck gold* is a kind of brass; *Mannheim gold* and *Similar* are also brass.

*Tulmi gold* is 90 copper, to 10 aluminum.

**Mosaic gold** is a definite chemical compound,  $\text{SnS}_2$ , stannic sulphide, made by heating in a flask at low red heat, 12 parts tin, 6 mercury, 6 ammonium chloride, and 7 flowers of sulphur; everything sublimes except the stannic sulphide which remains in the bottom of the flask. [The name "Mosaic gold" is sometimes given to substances other than stannic sulphide].

**Gold base plate:** different formulas are in vogue, but the constituents are in the main gold, copper, and silver; some contain platinum as well. 18 carat gold plate is made by two formulas: No. 1, contains 18 dwts. pure gold, 4 fine copper, 2 fine silver; No. 2 is 20 dwts. gold coin, 2 fine copper, 2 fine silver. Gold plate, 22 carats fine, is 22 dwts. pure gold, 1 dwt. fine copper, 18 grains silver, 6 grains platinum.

**Gold plate for clasps, wires, etc., etc.:** gold used for this purpose should contain sufficient platinum to render it firmer and more elastic. A 20 carat alloy for such purposes is made by 2 formulas: No. 1, is 20 dwts. pure gold, 2 fine copper, 1 fine silver, 1 platinum; No. 2, is 20 coin gold, 8 grains fine copper, 10 grains fine silver, 20 grains platinum.

245. **Pewter** is an alloy of variable composition, usually tin, lead, copper, and antimony or zinc. Plated pewter is 7 antimony, 2 bismuth, 2 copper, 89 tin. A pewter often used is tin 92, lead 8.

246. **Reese's alloy** is tin 20, gold 1, silver 2.

247. **Silver alloys and alloys resembling silver.**—

Silver coinage: silver 90, copper 10. Silver vessels: silver 95, copper 5. Silver jewelry: silver 80, copper 20.



An alloy used in England for temporary dentures is silver 24 parts, platinum 3 to 10 parts.

*German silver* contains no silver, but is an alloy of copper, nickel, and zinc, in the proportions of 40.4 copper, 31.6 nickel, 25.4 zinc, and sometimes 2.6 iron.

248. **Solders:** it is often necessary to unite several pieces of the same metal, or of different metals. For such work a kind of alloys called *solders* is used. Solders usually contain the metal on which they are to be used, together with some other metal or metals, which shall reduce the fusing point without affecting the color. [A solder suitable for use in prosthetic dentistry should fuse at a much lower temperature than the plate upon which it is to be used. Its color should be as nearly as possible the same, and it should withstand the action of the fluids of the mouth nearly as well. These properties may be obtained by the addition of small amounts of silver, copper, or brass. (Essig.)]

Solders have been divided into two classes: (*a*) solders made by the fusion of the metal itself, without others, and (*b*) solders made on a metal with another metal; or by an alloy applied to the surfaces which are to be united. In the last case the metal or alloy must be more fusible than the metal to be soldered, and have a more powerful chemical affinity for it.

*Hard* solder is used for metals difficult to melt, *soft* solder for those not so difficult.

249. **Common Solder** is an alloy of tin and lead. [Fine solder is 33.3 lead to 66.6 tin. Common solder is equal parts tin and lead; coarse solder is 66.6 lead, to 33.3 tin].

250. *Gold solder* is 22.2 copper, 66.6 gold, 11.1 silver. Formulæ 2 and 3 of Richardson are as follows:

No. 2—15 carats fine.  
6 dwts. gold coin.  
30 grains silver.  
20 grains copper.  
10 grains brass.

No. 3—18 carats fine.  
30 parts gold coin.  
4 parts silver.  
1 part copper.  
1 part brass.

251. *Silver solder* is 32.3 parts copper, 38.5 silver, 29.2 zinc. Others are as follows: (Richardson).

No. 1.  
Silver, 66 parts.  
Copper, 30 parts.  
Zinc, 10 parts.

No. 2.  
Silver, 6 dwts.  
Copper, 2 dwts.  
Brass, 1 dwt.

No. 3.  
Silver, 5½ dwts.  
Brass wire, 40 grains.

When the plate to be united consists of pure silver alloyed with platinum, the solder may be formed of the standard

metal (coin), with  $\frac{1}{10}$ th to  $\frac{1}{6}$ th its weight of zinc, according to the amount of platinum in the alloy.

252. *Aluminum solder* is 6 parts aluminum, 4 copper, 90 zinc. Others have been devised as follows:

	No. 1	No. 2	No. 3
Zinc .....	80	85	88
Copper.....	8	6	5
Aluminum.....	12	9	7

Aluminum may be soldered by coating it with copper as in electrotyping, then soldering as usual.

253. **Speculum metal** is an alloy of copper and tin; 66.6 copper, and 33.3 tin.

254. **Type-metal** is an alloy of 1 lead to 3 antimony. Sometimes lead 80, antimony 20. The best is said to be lead 75, tin 5, antimony 20.

255. **Phosphor bronze** is copper, combined with from 3 to 15 per cent. of tin, and from  $\frac{1}{4}$  to  $2\frac{1}{2}$  per cent. of phosphorus.

256. **Zinc and tin alloy** for casting dies for swaging plates is, according to Richardson, zinc 4, tin 1.

257. **Wood's metal**, according to Essig, is bismuth 7, lead 6, and cadmium 1. Fuses at 180° F. (See Fusible Alloys).

258. **Amalgams:** amalgam is the name given to an alloy of mercury and some other metal or metals. Mercury, it will be remembered, has the property of dissolving certain metals. The combinations formed are, in the case of solid amalgams, definite compounds in which, however, there is but feeble chemical affinity between the constituents. Liquid amalgams are merely solutions of the various metals in mercury, and not, as a rule, definite chemical compounds. Many liquid amalgams become, however, after a time white, solid, and crystalline. There is usually little or no contraction in volume, but in the case of silver and copper amalgams, there is considerable, and in tin and lead, slight, though perceptible. (Watts).

Amalgams are decomposed by heat.

The methods by which amalgamation may be made to take place are as follows:

1. Direct contact on part of the metal, either as a solid or in the finely divided state, with mercury, either at ordinary temperatures or at higher temperatures. Heat is evolved during the amalgamation.

2. Introduction of metallic mercury, or of sodium-amalgam, into a solution of a salt of a metal.

3. Introduction of a metal into a solution of a salt of mercury.

4. Contact of a metal with mercury, and addition of a dilute acid.

In the last two cases a weak electric current is sometimes developed.

**Antimony amalgam:** triturate 3 parts heated mercury with 1 part fused antimony; or triturate 2 parts antimony in a mortar, add a little hydrochloric acid, and gradually drop in 1 part of mercury. The amalgam is soft, decomposed by contact with air or water, and antimony separates.

259. **Cadmium amalgam:** cadmium amalgamates at ordinary temperatures. When complete saturation takes place, as through agency of sodium-amalgam in a solution of salt of cadmium, a compound of 78.26 Hg to 21.74 Cd is formed, having for its formula therefore  $Hg_2Cd$ , and being silver-white, granular, hard, brittle, heavier than mercury, and in octahedral crystals. (Watts).

260. **Cobalt amalgam:** introduce into an acid solution of cobalt chloride, supersaturated by ammonia, 5 parts of mercury, and 1 part of zinc. The amalgam is silver-white, soft, oxidizes on exposure to air to a black, pulverulent mass.

261. **Copper amalgam:** moisten *precipitated* copper\* (obtained by introducing a rod of zinc into a solution of a salt of copper, as copper sulphate) with solution of mercuric nitrate, then add hot water, and incorporate mercury by trituration. The amalgam is brittle at first, then softens, but becomes hard on keeping. It may be softened to consistence of clay by continued pounding or kneading, then, if left to itself, becomes hard and crystalline. Its specific gravity is the same, when soft as when hard, and it does not expand nor contract on hardening.

262. **Gold amalgam:** gold, in leaf or filings, amalgamates readily with mercury at ordinary temperatures. For rapid amalgamation, heat should be used, and the gold be in the finely divided state.

263. **Iridium amalgam:** made from sodio-iridic chloride and sodium-amalgam; is a semi-fluid mass.

264. **Palladium amalgam:** agitate solution of a salt of palla-

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\*This substance can be obtained of pharmacists.

dium with excess of mercury. A gray amalgam results, of composition,  $\text{Pd}_2\text{Hg}$ .

265. **Platinum amalgam:** metallic platinum does not unite readily with mercury. Spongy platinum unites with mercury, when triturated in a warm mortar with the latter, or in contact with acetic acid; or sodium-amalgam containing 1 per cent. sodium, if introduced into a solution of platinic chloride, will form an amalgam of silvery appearance. The amalgam containing 100 parts mercury, to 15.48 platinum, has a sp. gr. of 14.29, and has metallic lustre when rubbed, 100 mercury to 21.6 platinum is a dark gray solid; 100 mercury to 34.76 platinum is of 14.69 sp. gr., dark gray, but of no lustre; 100 mercury to 12 platinum is bright, but soft and greasy. The solid amalgam containing the most mercury is probably  $\text{PtHg}_2$ . Mercury exposed for some time to the action of platinic chloride forms a thick, pasty amalgam.

In general, it may be said that an amalgam of mercury and platinum alone does not harden well.

266. **Silver amalgam:** amalgamation takes place quickly, if the silver is in thin plates, or in powder, and dropped at red heat into heated mercury. The amalgam varies according to circumstances of formation, composition, etc., and is soft, or crystalline, or granular. The amalgam most readily formed has for its formula,  $\text{AgHg}$ . [Amalgams of mercury and silver are said by Watts to *contract* considerably, but by others to expand. The *proportions* are undoubtedly of importance.]

267. **Tellurium** and mercury are said to unite directly, forming a tin-colored amalgam.

268. **Tin amalgam:** made readily and quickly by pouring mercury into melted tin, but readily enough by mixing the filings with mercury at ordinary temperatures. Tin amalgam has a white color, and, if there is not too much mercury, occurs in form of a brittle, granular mass of cubical crystals. In most cases there is *condensation*, but in the amalgam composed of 1 part tin, to 2 mercury, (melted, and by volume) the condensation is scarcely perceptible.

269. **Zinc amalgam:** usually made by cooling melted zinc to as low a temperature as possible without letting it solidify, then pouring in mercury in a fine stream, and stirring constantly.

270. **Dental amalgam alloys:** it will readily be perceived from a study of common amalgams that few of them would be of service to the dentist. On the other hand combinations of

metals, often first melted in tin, brought about through the agency of mercury—that is, amalgams of *several metals at once*,—alloy amalgams—have been found very useful, so that now large quantities are used. Amalgams for dental purposes are chiefly composed of tin, and silver, in different proportions, of which Townsend's alloy of 60 tin, to 40 silver, may be taken as the type. Some dental amalgam alloys, as Hardman's and Lawrence's, contain copper in addition to tin and silver; some contain zinc, gold, etc. The list of metals used in the dental amalgam alloys comprises, tin, silver, copper, zinc, gold, platinum, cadmium, antimony, palladium. The so called "gold and platina alloys," according to Flagg, contain 50 per cent of tin, more than 40 of silver, and from 2 to 7 of gold and platinum.

[In regard to the average proportions of tin and silver, Flagg finds 40 tin to 60 silver the best working formula, modified by additions of copper, gold, and zinc, but in this he differs from others, most of whom use more tin than silver.]

271. **Qualities desirable in dental amalgam alloys:** strength and sharpness of edge, freedom from admixture with any metal favorable to the formation of soluble salts of an injurious character in the mouth, capability of maintaining its color and shape, and non-liability to undue expansion. N. B.—Absolute freedom from discoloration can not always be obtained nor is it always desirable, according to Flagg.

272. **Relative value of metals used for dental amalgams:** Flagg gives *silver* the position of first importance in dental amalgams. It expands on cooling, is essential to the proper setting of the amalgam, notably maintains the bulk integrity of the filling, and forms silver sulphide in contact with the sulphuretted hydrogen of the mouth. Although the tooth and the filling are discolored by the formation of silver sulphide, the latter is conducive to the preservation of the tooth.

273. *Tin* is given the second place, when in percentage in an alloy of from 35 to 48. Addition of copper and gold counterbalances the "shrinkage" caused by tin; sufficient silver can be used to obviate any loss of edge strength, which would be of detriment, and retardation is prevented. Tin greatly increases the facility of amalgamation, aids in producing good color, prevents discoloration, and diminishes conductivity. According to Essig, if an amalgam of silver and tin contain no excess of mercury, discoloration is not likely to be observed to a marked degree.

274. *Copper* is regarded as a most valuable component of

dental amalgams. It diminishes shrinkage, in that copper amalgam neither expands nor contracts; it favors rapid setting; it adds to the immediate whiteness of amalgam; its tendency to gradual discoloration can be controlled by addition of gold. It is thought to add to the compatibility of the filling material with the tooth-bone, and to promote toleration of foreign material in close proximity to dental pulp. [Flagg says that he would not permit in his practice any metal filling to approach a pulp unless it should contain either copper or tin.] The sulphide of copper formed by the action of the sulphuretted hydrogen of the mouth on the copper of the amalgam is, according to Tomes, readily converted, on exposure to air and moisture, into copper sulphate, hence it is almost certain that the latter is formed on the exposed surface of the filling. Cupric sulphate is freely soluble, and hence is likely to permeate the dentine. Sulphides of the other metals are not so readily converted into soluble salts, hence will not permeate the dentine so thoroughly.

Prof. A. O. Hunt is my authority for the statement, that when the "mounds" of the "mound builders" are opened, he has noticed that those skeletons which are surrounded by copper ornaments are well preserved, but those which are not, readily crumble.

275. *Gold*, more than any other metal, in proportion to the small amount required, diminishes shrinkage, increases rapidity of setting, imparts fine grained plasticity, controls maintenance of color, and secures desirable edge strength for amalgams. Its value is that of a balancing power. Flagg thinks that the best proportion of gold is from 5 to 7 per cent., its value depending entirely on accurate proportionment of every other component of the amalgam alloy.

276. *Platinum*, according to Essig, is of value only when combined with tin, silver, and gold, with the proper amount of mercury; under such circumstances, it seems to confer on the alloy the property of almost instantly setting, and of being much harder.

277. *Antimony* controls shrinkage, and imparts fine grained plasticity. Objection to its use is the soiling of the hands, produced in mixing and working amalgams containing it.

278. *Zinc* controls shrinkage, imparts plasticity to the amalgam, giving it an exceptionally fine working quality, adds to the whiteness of the filling, and to the maintenance of



color. Zinc is not discolored by sulphuretted hydrogen. The percentages used have been from less than 1 up to  $1\frac{1}{2}$ .

279. *Cadmium* amalgamates easily, sets quickly and resists sufficiently, but fillings containing it gradually soften, and disintegrate, and if there is a large proportion the dentine becomes decalcified, and stained bright orange-yellow, from formation of cadmium sulphide.

280. **Discoloration of amalgam fillings:** the formation of sulphides, due to the sulphuretted hydrogen resulting from the decomposition of the food, is the main cause of the discoloration of amalgam fillings, and black discoloration is found in fillings containing *silver*, or *copper*; yellowish discoloration in those containing *cadmium*. The mercury is said to play no part in the discoloration, as it gradually disappears from the alloy. According to Essig, it is not safe to suppose that a metal not of itself blackened by sulphuretted hydrogen—as gold or platinum—will secure the same immunity to alloys containing silver and mercury. It has been noticed that plugs, which apparently exclude the passage of a solution of indigo or ink, will show peripheral discoloration, when exposed to the action of a sulphuretted hydrogen solution, though the surface directly exposed to the action of the sulphur was but slightly clouded. (Essig).

281. **Toxicology of Dental Amalgam Alloys:** Flagg insists that he has never seen any case where the slightest symptom could reasonably be ascribed to mercurial action. On the other hand, Talbot and Haines have conducted experiments which go to show that vapor of mercury is given off from all amalgams, causing ptyalism, etc., etc.

It must be remembered that some individuals are susceptible to the action of incredibly small quantities of mercury.

282. **Cements:** those chiefly used are the gutta percha, oxychloride of zinc, oxysulphate of zinc, and oxyphosphate of zinc. These are not alloys of metals, for no fused metals are used in them, nor are they amalgam alloys, for no mercury is used to combine any metals.

283. **Gutta-percha** is described under the head of Organic Chemistry.

**Hill's stopping:** the preparation known as "Hill's stopping" is composed of gutta percha, quicklime, and feldspar, the two last being incorporated with the first, while the latter is in a plastic condition, from the effects of heat. [Oil of encalyptus dissolves gutta percha, hence should not be brought into contact with Hill's stopping].



284. **Oxychloride of zinc** is made from oxide of zinc and chloride of zinc. Morsman's formula for preparing *zinc oxide* is as follows: take of zinc oxide, U. S. P., and pure nitric acid, equal parts by weight. Spread the oxide upon a large glass slab, and sprinkle or drop the acid upon it, little by little. Mix with a wooden spatula, transfer to a crucible, and subject to a strong heat, until it is bright yellow. Maintain it at this point for about 30 minutes. Remove, and, when cold, reduce to fine powder in a mortar, and pass through a fine sieve. The solution of chloride of zinc is made by Morsman as follows: take chloride of zinc one ounce, water, one fluidrachm. Dissolve, let stand, and filter, or decant. For a slow-setting cement dissolve the chloride in half a fluidounce of water.

[It is better to decant chloride of zinc solutions than to attempt filtration, unless through purified asbestos, or powdered glass. After the solution has stood until any undissolved portion has settled to the bottom, pour off the supernatant liquid down the side of a glass rod, into the receptacle used. AURNOR]. To make the oxychloride itself, push a little of the powder into a drop of the liquid.

According to Morsman the oxide of zinc, which has been calcined with nitric acid, makes a better cement than either the commercial oxide of zinc, or the U. S. P. officinal oxide. It should be re-calcined from time to time, or a fresh amount made, as it does not keep over three months. Use of the nitric acid in calcining oxide of zinc, according to Morsman, causes a difference in the product, which is less bulky than the official oxide, but just as heavy. [The nitric acid is probably expelled by the heat—AURNOR].

285. **Oxyphosphate of zinc**, is made from zinc oxide, and phosphoric acid. The oxide of zinc is to be prepared, according to Morsman, in the same manner as described above, under the head of oxychloride.

The liquid is to be prepared as follows: take of *glacial* phosphoric acid one ounce, and of rain water two fluidounces; dissolve by *gentle* heat, and filter through paper; place in a glass or porcelain capsule, and evaporate over a sand bath, until the fluid begins to thicken. Allow to cool gradually. Crystals form. After two or three days, pour off the liquid for use. If it does not work satisfactorily, add a little water—two or three drops at a time. Some prefer to use crystals instead of liquid; if this be desired, the solution should be

evaporated, over the sand bath, till thick while hot: let cool, and when crystals form, drain them dry.

I think it advisable to prepare the liquid fresh from time to time, although Morsman finds that the deterioration of the liquid, after three months, can be offset by the addition of a few drops of water. According to him, a cement is unfit for use whenever it hardens quickly on addition of a small amount of powder, becoming somewhat granular and, if worked with the spatula, again soft.

I have already shown under the head of phosphoric acid (1) that the common phosphoric acid is liable to fungous growth, deterioration, and loss in specific gravity, and (2) that the glacial acid slowly changes, spontaneously, into the common acid; quickly, if boiled with water. It would seem, so far as I can ascertain, that the glacial acid makes satisfactory cements; two liquids given me to examine, with the assurance from dentists that they are entirely satisfactory, I have found to be glacial phosphoric acid. To mix the powder and liquid for the oxyphosphate cement, Flagg directs that a portion of fluid equal to one or two drops, or ten grains of melted crystals, should be placed on a glass slab, and considerable powder placed near it. Equal bulk of powder should then be mixed with the fluid by means of a spatula, until a mixture of thick creamy consistence is obtained, then a little more powder should be added, and quickly and forcibly made into mass, by thorough use of spatula. The mass should be of putty-like consistence, and, after "kneading," and rolling into a pellet, is ready for insertion.

286. Oxysulphate of zinc is made by thoroughly calcining zinc sulphate, at a glowing red heat, reducing to fine powder when cool, and adding to it two or three parts of calcined oxide of zinc. The resulting powder should be kept in a tightly stoppered bottle. The powder is to be dissolved in a liquid, made by dissolving 15 grams of gum arabic in half an ounce of pure water, to which when complete solution has taken place, 1 grain of calcium sulphite is added, and the whole filtered through absorbent cotton.

287. **Chemistry of various substances of interest to the dentist:**

288. **Artificial teeth:** teeth are composed of two portions, the *body* or *base*, and the *enamel*. The constituents of the body are chiefly *silex*, *feldspar*, and *kaolin*. The enamel is composed principally of *feldspar*. Coloring matters are also used, and consist of various metals, in a state of minute division, or of metallic oxides.

289. **Silex** is the term given by dentists to what chemists call silica,  $\text{SiO}_2$ . For dental uses it is prepared by raising to white heat, plunging into cold water, and grinding to fine powder.

290. **Kaolin** is essentially a silicate of aluminum. It usually contains oxide of iron, and some other substances, as magnesia, potash, etc., etc. It is the result of the decomposition of feldspar. Relatively large proportions of kaolin give teeth an opaque and lifeless appearance; modern mineral teeth contain less kaolin, and more feldspar. It is prepared for dental uses by washing, letting settle, decanting, letting settle, decanting again, and drying in the sun.

291. **Feldspar** is a double silicate of aluminum and potassium, its composition being represented by the formula  $\text{K}_2\text{Si}_3\text{O}_7$ ,  $\text{Al}_2\text{Si}_3\text{O}_9$ . It also contains lime and oxide of iron. It is prepared for dental uses in the same way as silex. It is readily fusible.

292. **Coloring materials** consist chiefly of the following:

TABLE 24—COLORING MATTERS OF ARTIFICIAL TEETH. (RICHARDSON.)

METAL OR OXIDE.	COLORS PRODUCED.
Gold in minute division:	Rose red.
Oxide of gold:	Bright rose-red.
Platinum sponge and filings:	Grayish blue.
Oxide of titanium:	Bright yellow.
Purple of Cassius:	Rose purple.
Oxide of uranium:	Greenish yellow.
Oxide of manganese:	Purple.
Oxide of cobalt:	Bright blue.
Oxide of silver:	Lemon yellow.
Oxide of zinc:	Lemon-yellow.

[The chemical composition of most of these substances, used as coloring matters, has already been given. A few of them, being of importance as coloring matters only, are now described.]

293. **Titanic oxide**,  $\text{TiO}_2$ , occurs in various minerals known as *rutile*, *anatase*, and *brookite*.

294. **Oxide of uranium**,  $\text{U}_2\text{O}_3$ , is prepared from a mineral called *pitch-blende*.

295. **Oxide of manganese**,  $\text{MnO}_2$ , in minute quantity imparts a purple color, probably due to the formation of an oxy-silicate. It occurs as the mineral *pyrolusite*.

296. **Purple of Cassius** is a pigment produced by treating

gold chloride with a solution of stannous chloride, or it may be prepared by adding stannous chloride to a mixture of stannic chloride and auric chloride, as follows: 7 parts of gold are dissolved in aqua regia, and mixed with 2 parts of tin also dissolved in aqua regia; this solution is largely diluted with water, and a weak solution of 1 part tin in hydrochloric acid is added, drop by drop, till a fine purple color is produced. The purple of Cassius remains suspended in water, but subsides gradually, especially if some saline substance be added. (Bloxam). Bloxam believes its constitution to be indicated by the formula,  $\text{Au}_2\text{OSnO}_2, \text{SnOSnO}_2, 4\text{H}_2\text{O}$ .

297. **Oxide of Silver**,  $\text{Ag}_2\text{O}$ , is obtained as a brown precipitate, when solution of silver nitrate is decomposed by potash. Take of silver nitrate 100 Gm., of distilled water 200 C.c., of solution of potassa (official) 600 C.c. Dissolve the silver nitrate in water, and add solution of potassa as long as any precipitate is produced by it. Wash the precipitate with distilled water, until the washings are nearly tasteless. Dry the product and keep it well protected from the light.

It parts with its oxygen easily and must not be heated nor brought into contact with ammonia. Should be kept in a well-closed bottle and in a cool place. (O. & L.)

298. **Oxide of Gold**, see **Auric Oxide**.

299. **Crown enamels** are composed of feldspar, as a basis, with various coloring matters, such as titanium, spongy platinum, oxide of gold. Of the different kinds of feldspar, Richardson prefers the *Boston Spar*, on account of its greater fusibility.

300. In some cases a **flux** is used, composed of "silex, borax, and sal tartar." Salt of tartar is pure potassium carbonate.

301. *Grayish-blue enamels* may contain platinum sponge, and oxide of gold; *yellow enamels* may contain, in addition, a considerable percentage of titanium.

302. Various **frits** are sometimes used: the term **blue frit** is given to a mixture of feldspar  $\frac{1}{2}$  oz., and platinum sponge 4 dwts., powdered finely, made into a ball with water, fused very slightly, plunged into water while hot, dried, and finely pulverized. **Yellow frit** consists of  $\frac{1}{2}$  oz. spar to 2 dwts. of titanium. **Gold mixture** consists of 8 grs. of gold dissolved in aqua regia, and mixed with  $12\frac{1}{2}$  dwts. of very finely pulverized spar.

**Gum frit** (1) is composed of feldspar, flux, and oxide of gold. **Gum frit** (2) is composed of spar, flux, and purple of Cassius.

303. **Continuous gum materials** are, according to Hunter's formulas, composed of silex, fused spar, calcined borax, fused caustic potash, asbestos, granulated body, flux, base, gum enamels, covering, investient, cement, alloy.

The *calcined borax* is prepared by heating commercial borax, in a covered vessel, over a slow fire.

The *caustic potash* should be the best, and that known as *fused* is preferred, prepared by dissolving impure potassa in alcohol, removing undissolved portions, distilling off the alcohol, and fusing in a silver capsule.

*Asbestos* is essentially a silicate of magnesium and calcium, and is fibrous in structure. It should be free from all foreign substances, as talc, or soapstone.

*Granulated body* is spar, silex, and kaolin.

The *flux* used is composed of 8 parts silex, to 4 of calcined borax, and 1 of caustic potash.

The *base* is flux, asbestos, and granulated body.

The *gum enamels* are of various composition, but contain flux, fused spar, and English rose. (See paragraph 304).

The *covering* is the same as the gum, without the English rose, with or without coloring of titanium.

The *investient* is composed of white quartz sand, plaster-of-Paris, and water.

The *cement* is 1 part wax to 2 of rosin.

The *plate* or *base* is formed of platinum, platinum and iridium, or of aluminum.

The *solders* used are pure gold, or a mixture of gold and platinum. Common gold solder will not answer, as copper alloy gives a greenish shade, and silver a yellow tinge.

304. **The dry method of preparation of gum-enamel** as practised by Wildman and described by Essig is divided into three stages: first, the preparation of the oxide; second, fritting, or, by aid of heat, uniting the metallic oxide with a silicious base; and, third, diluting the frit so as to form the desired shade. In this method, the purple of Cassius (metallic oxide) is prepared in the dry way by fusing silver, gold, and tin with borax, removing borax glass formed, dissolving the silver with nitric acid, washing well and drying. The frit is formed by mixing the purple of Cassius thus made with a flux composed of quartz, borax glass, sal tartar. Lastly, the frit is diluted with the proper amount of feldspar.

305. **Dental rubber:** for dental uses, India-rubber is prepared for vulcanizing by incorporating with it either sulphur

alone or some of its compounds, and a coloring matter added, in many cases mercuric sulphide (vermilion); white clay, oxide of zinc, and calcium carbonate are also used. Para rubber is the kind used, the vermilion being added when a "red rubber" is desired, and the oxide of zinc or some form of aluminum silicate, as white clay, when a "white rubber." "Black rubbers" are the direct result of vulcanizing the rubber with sulphur, no pigment being added. It is claimed that the various pigments when in large percentage produce soft, inflexible rubbers. Difference in shade of red is supposed to be due to difference in percentage and kind of vermilion used. The term **vulcanite** is given to caoutchouc mixed with half its weight of sulphur.

306. **Celluloid base** consists essentially of celluloid which is composed of pyroxylin, camphor, oxide of zinc, and mercuric sulphide. (See Organic Chemistry for Pyroxylin and Camphor).



## CHAPTER VIII.

### CARBON COMPOUNDS OR ORGANIC CHEMISTRY.

#### 307. Organic Theory.—

1. *Organic Chemistry* is the chemistry of carbon compounds.

2 The *elements* contained by organic compounds are, besides carbon, chiefly hydrogen, oxygen and nitrogen, sometimes sulphur and phosphorus.

3. *The general properties* of organic compounds are as follows: combustible (except  $\text{CO}_2$  and its salts); solids usually when carbon atoms predominate in their molecule; liquids or gaseous when hydrogen predominates; easily volatilized gases or liquids when a small number of atoms in the molecule; liquids of high boiling points or solids when number of atoms in the molecule is large.

4. *Quantitative analysis* more important than qualitative to establish identity of organic compound. If the elements of an organic substance are determined, the analysis is called *ultimate* or *elementary*; if different organic substances when mixed together are separated, the analysis is called *proximate*.

5. The presence of *carbon* in a combustible form will prove a compound to be organic; hence, if a substance burns with generation of carbon dioxide (shown by passing the gas through lime-water), the organic nature of this substance is established. The presence of *hydrogen* may be shown by allowing the gaseous products of combustion to pass through a cool glass tube, when drops of water will be deposited. To show presence of *nitrogen*, heat with a mixture of two parts calcium hydrate to one part sodium hydrate (soda lime); the nitrogen is converted into ammonia, recognized by its odor and action on paper moistened with copper sulphate solution.

6. A chemical *formula* is called *empirical* when it gives the simplest expression of the composition of a substance;

this formula, however, does not necessarily denote the actual number of atoms in the molecule, which may be two or three times the number given in the empirical formula; thus, the empirical formula of acetic acid is  $\text{CH}_2\text{O}$ , but the actual molecular formula contains twice the number of atoms, or  $\text{C}_2\text{H}_4\text{O}_2$ . Besides empirical and molecular formulæ, others called *rational*, *constitutional*, *structural* or *graphic* are used. The molecular formula of acetic acid is  $\text{C}_2\text{H}_4\text{O}_2$ , but the formula  $\text{HC}_2\text{H}_3\text{O}_2$  shows that acetic acid, like nitric acid  $\text{HNO}_3$ , is monobasic, containing one atom of hydrogen, which can be replaced by an atom of a metal; hence  $\text{HC}_2\text{H}_3\text{O}_2$  is called a *constitutional* formula.

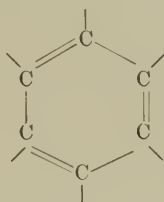
7. *Radicals or residues.* These are expressions for unsaturated groups of atoms known to enter as a whole into different compounds, but having no separate existence. Water  $\text{H}_2\text{O}$  is a *saturated* compound that is the one atom of oxygen—which is a dyad, and may be said therefore to have *two* points of attraction—combines with two of hydrogen; and therefore has both its points of attraction satisfied. If now one atom of H be taken from  $\text{H}_2\text{O}$ , there is left the group of atoms HO, which is called a radical, as it consists of an atom of oxygen, in which but one point of attraction is actually saturated, the second one not being provided for; moreover, this group HO occurs in many compounds—as, for example, in the hydrates, as potassium hydrate, KHO, etc. The *equivalence* of radicals depends upon the number of points of attraction unprovided for: carbon requires four atoms of hydrogen to provide for its points of attraction; therefore,  $\text{CH}_3$  would be a *monad* radical,  $\text{CH}_2$  a dyad, CH a triad.

8. *Chains:* the expression *chain* denotes a *series* of atoms, held together in such a manner that affinities are left unsaturated. The atoms of the series must have a greater equivalence than one, *i. e.*, must be dyad, etc. The existence of such an enormous number of carbon compounds is greatly due to the property of carbon to form these chains. (Simon). Carbon is a tetrad, hence two atoms would form a chain as follows:

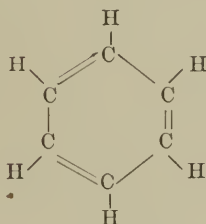
$$\begin{array}{c} | & | \\ -\text{C} & - & \text{C}- \\ | & | \end{array}$$
 each atom has four bonds, one of which unites with one of the other, leaving in this particular chain six free affinities. Three atoms of carbon would be:

$$\begin{array}{c} | & | & | \\ -\text{C} & - & \text{C} & - & \text{C}- \\ | & | & | \end{array}$$
 four, 
$$\begin{array}{c} | & | & | & | \\ -\text{C} & - & \text{C} & - & \text{C} & - & \text{C}- \\ | & | & | & | \end{array}$$
 etc., etc. The free

affinities may be saturated with various atoms or radicals, hence the almost unlimited number of possible combinations. Atoms are not always united by one affinity. When they are united by *two*, the expression for two atoms of carbon would be  $\diagup\text{C} = \text{C}\diagdown$ ; if by three,  $\text{C}\equiv\text{C}-$ . In the so-called *closed chain* of  $\text{C}_6$  we have the atoms united partially by double and partially by single union:



Benzine,  $\text{C}_6\text{H}_6$ , would then be represented as follows:



It is easy to see from these two diagrams the origin of the term *skeleton*, which is sometimes used instead of chain.

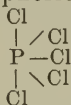
9. *Homologous series*. Any series of organic compounds, the members of which preceding or following each other differ by  $\text{CH}_2$ , is called a homologous series.

10. *Types*. Most substances may be classified under the five following types:

I.	II.	III.	IV.
Hydrogen.	Water.	Ammonia.	Methane.
$\text{H}-\text{H}$	$\text{H}-\text{O}-\text{H}$	$\begin{array}{c} \diagup \text{H} \\ \text{N}-\text{H} \\ \diagdown \text{H} \end{array}$	$\begin{array}{c} \text{H} \\   \\ \text{C} \diagup \text{H} \\   \diagdown \text{H} \\ \text{H} \end{array}$

## V.

## Phosphoric chloride.



Almost any compound may be classed in one of these types by replacing the constituents of these types by other elements or radicals of the same equivalence.

10. *Substitution*. Replacement of an atom or group of atoms by other atoms or groups:  $\text{C}_6\text{H}_6 + \text{HNO}_3 = \text{C}_6\text{H}_5\text{NO}_2 + \text{H}_2\text{O}$ . Here for one atom of hydrogen in benzene ( $\text{C}_6\text{H}_6$ ) has been substituted the group  $\text{NO}_2$ .

11. *Derivatives*. Chloroform  $\text{CHCl}_3$  is a *derivative* of marsh gas,  $\text{CH}_4$ , because it may be obtained from the latter by replacement of three atoms of hydrogen by three of chlorine. The term is applied to bodies derived from others by some kind of decomposition, generally by substitution.

12. *Isomerism*. Two or more substances having the same elements in the same proportions by weight, or having the same percentage composition, and yet being different bodies with different properties, are called *isomeric* bodies. When two or more substances have the same molecular formulæ they are said to be *metameric* with one another; thus  $\text{CN}_2\text{H}_4\text{O}$  is either urea or ammonium cyanate; hence, urea is said to be metameric with ammonium cyanate. Sometimes structural formulæ will serve to distinguish two substances metameric with each other. When a substance contains some multiple of the number of each of the atoms contained in the molecule of the other, it is said to be *polymeric* with it; thus acetic acid,  $\text{C}_2\text{H}_4\text{O}_2$ , is polymeric with grape-sugar,  $\text{C}_6\text{H}_{12}\text{O}_6$ .

13. *Decomposition*. A molecule may undergo various changes; its atoms may re-arrange themselves; it may split up into two or more molecules; two molecules may unite to form one; atoms may be removed from it without replacement by other atoms; atoms may be removed and replaced by others. Organic bodies decompose readily under the influence of heat or chemical agents. Heat will volatilize some organic bodies without decomposition; whilst others are decomposed by it with generation of volatile products. *Dry or destructive distillation* is the term applied to the process of heating non-volatile organic substances in such a way that the oxygen of

the air has no access, and to such an extent that decomposition takes place.

14. *Combustion and decay.* In common combustion, provided an excess of atmospheric air be present, the carbon of an organic substance is converted into carbon dioxide, the hydrogen into water, sulphur and phosphorus into sulphuric and phosphoric acids, and the nitrogen set free. In decay, which is slow oxidation, the compounds mentioned above are finally produced, but many intermediate products are also generated. Alcohol when burned forms carbon dioxide and water; exposed to the air, it undergoes slow oxidation, forming aldehyde first, then acetic acid.

15. *Fermentation and putrefaction.* An organic substance, under favorable temperature and during the presence of moisture and of a substance termed a ferment, undergoes a peculiar kind of decomposition, during which its molecule is split up into two or more molecules of a less complicated composition.

16. *Difference between fermentation and putrefaction.* The term *fermentation* is used in those cases where the decomposing substance contains carbon, hydrogen and oxygen only. When it contains these three, and also nitrogen or sulphur, or both, the term *putrefaction* is used. Sugar,  $C_6H_{12}O_6$ , ferments: albuminous substances, containing nitrogen and sulphur, putrefy, and the nitrogen and sulphur being evolved as ammonia and sulphuretted hydrogen, an offensive odor is noticed. Ferments are prevented from action by the presence of the so-called *antiseptic* agents (carbolic acid, salicylic acid, salt, etc.) If air be excluded, ferments are excluded, inasmuch as the atmospheric air is filled with millions of minute germs of organic nature, which germs may act as ferments when in contact with organic matter under otherwise favorable conditions. By enclosing substances in air-tight vessels which when filled are heated sufficiently to destroy any germs which may have been present, the action of ferments is counteracted. (Simon).

17. *Action of various agents on organic matter.* Chlorine and bromine usually remove or replace the hydrogen of an organic substance. Sometimes they combine directly with it, and sometimes, in presence of water, act as oxidizing agents by combining with the hydrogen of the water and liberating oxygen. Nitric acid either forms (i) salts with organic matter, (ii) oxidizes it, or (iii) substitutes  $NO_2$  (nitryl) for hydrogen. In the latter cases the additional quantity of oxygen

added renders the compounds highly combustible, or even explosive. Substances having a great affinity for water, as, for example, sulphuric acid, act on many organic substances by removing hydrogen and oxygen, leaving dark or black compounds consisting mainly of carbon. Alkalies may combine directly, form salts, form soaps, oxidize, or evolve ammonia from nitrogenous compounds. Reducing agents, especially nascent hydrogen, either combine directly, remove oxygen or replace oxygen.



## CHAPTER IX.

### HYDROCARBONS.

308. **Group I. Paraffines:** The general formula for this series is  $C_nH_{2n+2}$ , which means that, however many carbon atoms a paraffine contains, it will contain *twice* as many hydrogen atoms, and two more. Thus marsh gas, a member of this series, contains one atom of carbon; one multiplied by two and two added to the product equals *four*, therefore the number of hydrogen atoms is *four*, and the formula is  $CH_4$ .

American petroleum contains many members of this series. They are isolated from petroleum by *fractional distillation*. This process may be conducted in the following manner: the liquid to be distilled is placed in a retort, through the tubulure of which a thermometer passes to indicate the temperature at which the substance boils. The first portion, which distills over, will consist chiefly of that liquid which has the lowest boiling point, and, if the receiver be changed at stated intervals corresponding to a certain rise in the temperature, a series of liquids will be obtained, containing substances the boiling-points of which lie within the limits of temperature between which such liquids are collected.

#### 309. **Petroleum or Mineral Oil.**—

This substance, known also as *rock oil* or *liquid bitumen*, is a natural product, consisting of a number of hydrocarbons, together with small quantities of sulphuretted, oxygenized, and nitrogenized bodies. It contains about 85 per cent. of carbon, and 15 of hydrogen.

310. Among the products obtained from petroleum are *rhigo'ene*, *gasoline*, *naphtha*, *benzine*, and *kerosene*.

311. **Rhigolene:** one of the lighter and more volatile products of petroleum. It is the lightest known substance, sp. gr. from 0.590 to 0.625. Highly volatile, inflammable, boils at  $70^{\circ}F$ , colorless, odorless when pure. It is used for produc-

ing local anæsthesia. Most specimens of it have a disagreeable odor of petroleum. It should be kept in a cool place, in a tightly stoppered flask, and should not be brought near a light, nor used at all at night.

312. **Gasoline:** this substance is the lightest and most volatile portion of petroleum "naphtha", and is employed for naphthalizing gas and air. Its specific gravity is from 0.650 to 0.665. It boils at 119°F.

313. **Naphtha** has a density of from 0.695 to 0.705, and is often an adulterant of kerosene.

314. **Mineral Naphtha** or "**benzine**": this substance should not be confused with *benzene*. "Benzine" is a petroleum product, while benzene is a coal-tar product. The synonyms of "benzine" are petroleum spirit, petroleum naphtha, shale naphtha, benzoline.

It is a thin, colorless, liquid of 0.69 to 0.74 sp. gr., inflammable, volatile. It dissolves gutta serena, naphthalin, paraffine wax, and many similar substances. It is used as an illuminating agent in sponge lamps.

315. **Mineral burning oil or kerosene:** American petroleum yields from 50 to 70 per cent. of its weight of kerosene, which is also called refined petroleum, photogene, and paraffine oil.

It is a solvent of sulphur, iodine, phosphorus, camphor, wax, fats, many resins. It softens india-rubber to a glairy varnish. Its sp. gr. is from 0.78 to 0.82. Good lamp oil should neither be too viscous, nor too volatile, and should have a tolerably high boiling point. Cold oil of good quality will not take fire, when a light is applied to it, nor should its vapor inflame. New York State law declares that oils used for illuminating purposes shall not give a vapor that will "flash" below 100°F., nor shall themselves ignite below 300°F.

316. **Vaselene or vaseline.**—

Synonyms: cosmoline, saxolene, petroleum jelly.

Theoretical constitution: vaselene is a mixture of hydrocarbons, consisting chiefly of those whose formulæ are from  $C_{16}H_{34}$  to  $C_{20}H_{42}$ , together with some of the olefine series.

Preparation: vaselene consists of those portions of petroleum which, at ordinary temperatures, are soft or pasty. The last distillate or the undistilled portion is treated with superheated steam, and filtered through animal charcoal.

Properties and uses: colorless or pale yellow, odorless, translucent, slightly fluorescent, neutral, semi-solid. Its sp. gr., when melted, is 0.840 to 0.866, and it melts from 95°F. to

104°. It is insoluble in water, nearly in alcohol, freely soluble in ether, chloroform, benzene, carbon disulphide and turpentine. It is miscible in all proportions with fixed and volatile oils. It forms an intimate mixture with glycerine. It dissolves sulphur, iodine, bromine, carbolic acid, atropine, strychnine, phosphorus, benzoic acid, iodoform (when melted). It can not saponified nor does it become rancid; hence is a valuable agent in ointments. It is but little affected by chemical reagents. It is a valuable substitute for lard, in the preparation of ointments containing sulphur, the iodides, compounds of lead, zinc, and mercury.

Use in dentistry: vaseline is used as an application to inflamed surfaces, as a dressing in periostitis, and as an emollient after devitalization or removal of dental pulps.

317. Group 2. Olefines: the olefines are unsaturated compounds, having a general formula of  $C_nH_{2n}$ . Ethylene and amylene are important members.

318. **Ethylene:**  $C_2H_4$ . This substance known as olefiant gas is found in coal-gas, and gives it illuminating power. It combines directly with chlorine, forming a thick, oily liquid, known as **dichloride of ethylene**,  $C_2H_4Cl_2$ , used as a local, and general anæsthetic; it is usually obtained in the manufacture of chloral, and is very much like chloroform. It is sometimes called "Dutch liquid."

319. **Amylene:**  $C_5H_{10}$ . This body is obtained by distilling fusel oil (amylic alcohol) with chloride of zinc. It is a colorless, very mobile liquid, boiling at 102°, and of vapor density 2.45. It has a disagreeable odor. It has been used as an anæsthetic. The name should not be confounded with *amylin*, a synonym of dextrin.

320. **Mineral lubricating oil:** the various products known by this title are obtained from the less volatile fluid portions of petroleum. It consists chiefly of higher members of the olefine series. Its color ranges from pale yellow, through all shades of red, brown, green and blue, to black. Good qualities have very little taste, and no marked smell, even when heated.

321. Group 3. Hydrocarbons of the *fourth* series. General formula,  $C_nH_{2n-4}$ .

Hydrocarbons of the *third* series,  $C_nH_{2n-2}$ , are of no importance to the dentist. Those of the *fourth* series include turpentine, and a large number of oils, essential or volatile, so-called. These different essential oils are mostly isomers

or polymers, having for a formula  $C_{10}H_{16}$ , or some multiple of it.

322. **Oil of turpentine:**  $C_{10}H_{16}$ , called also spirit of turpentine and essence of turpentine, obtained by distilling turpentine or oleo-resinous juice, exuding from various kinds of pine.

It is a colorless, mobile liquid, having peculiar, aromatic, and disagreeable odor; acrid, caustic taste; does not mix with water; soluble in alcohol; dissolves iodine, sulphur, phosphorus, fixed oils, resins, etc.; exposed to the air absorbs oxygen, becomes thicker, finally resinous. After prolonged contact with air, becomes ozonized. Sp. gr., 0.864. Boiling point,  $312^{\circ}F$ . It is miscible in all proportions, or at least very soluble in ether, carbon disulphide, chloroform, benzene, petroleum spirit, fixed and essential oils. It dissolves fats, waxes, resins, and caoutchouc.

323. *Sanitas oil* is made by oxidizing oil of turpentine, floating on water, by a stream of heated air. [It contains, according to Harlan, camphoric acid, and hydrogen dioxide—see above on ozonization of turpentine in contact with air].

324. **Terpenes, terpin, terebene, etc :** there has been great confusion in regard to the names of these substances.

*Terpene* is the general name for hydrocarbons having  $C_{10}H_{16}$  or some multiple for their composition. Thus, for example, pure oil of turpentine,  $C_{10}H_{16}$ , is called a terpene. [*Camphene* has been used as a general term for terpenes, but it is also used for a particular kind of terpene].

*Terpene* is not the same as terpin or terpine; terpin is a particular member of the group, to which the general name terpene is given. Terebene is a terpene. Terpenes are either natural or artificial; the natural terpenes occur in oil of turpentine; the artificial are camphene, terebene, menthene, cajuputene, etc., etc. The derivative from *French oil of turpentine only*, is called terpene hydrate. Derivatives from any oil of turpentine are terpene hydrochloride, terpin hydrate, terpin, terpinol, etc., etc.

325. **Terebene:** this substance,  $C_{10}H_{16}$ , isomeric with oil of turpentine, is an artificial terpene produced by the action of sulphuric acid on oil of turpentine. It is a molecular modification of essence of turpentine. It is a clear, colorless liquid and an agreeable remedy, having an odor like that of freshly sawn pine wood. It does not mix with water. It imparts a very distinct odor of violets to the urine.

Dr. Wm. Murrell, of London, has employed terebene for

the last five years and has made experiments to ascertain its properties. In the proportion of one to five hundred it checks, and in one to one thousand prevents, fermentation.

It absorbs oxygen readily, and is a disinfectant, and antiseptic. It dissolves in the various essential oils, and is a solvent for gutta percha, iodine, and resins. It is soluble in 10 parts of alcohol. Its sp. gr. is 0.860, and it boils at 313°F. Most commercial terebenes are contaminated with resin, turpentine, and dioxide of hydrogen. It is, however, almost impossible to prevent the formation of hydrogen dioxide in terebene, which, so far as topical action is concerned, does no harm, but is of advantage. Iodol and terebene are now used, in proportions as follows: iodol, 10 grains, terebene, 1 fluid ounce.

Terebene is used in dentistry as an antiseptic, disinfectant, and stimulant.

326. **Terpin:** and **terpin hydrate:** the "terpin" used in medicine should preferably be called terpin hydrate, as it is not properly terpin. Nor is it by any means *terpene* hydrate. The substance now used as an expectorant is  $C_{10}H_{16} (H_2O)_2$ ,  $H_2O$ . It occurs in large, transparent crystals.

327. **Essential or volatile oils:** theoretical constitution: most of the volatile oils of plants are terpenes, that is hydrocarbons of formula  $C_{10}H_{16}$ ; others are polymers of terpenes, of formula  $C_{15}H_{24}$ . The hydrocarbons of plants are liable to change in contact with air or moisture, so that they are not found in the pure state, even when freshly obtained. Some essential oils consist mostly of certain ethers, some of aromatic aldehydes.

**Preparation:** the volatile oils of plants may be obtained, either by *pressure*, as in case of oils of laurel, lemon or bergamot; by *distillation* with water, or by passing a current of *steam* over the matter to be extracted; by *fermentation and distillation*, as with oils of mustard and bitter almonds; by *solution in a fixed oil*.

**General properties:** essential oils of plants are liquid at ordinary temperatures, but deposit solid matters in severe cold. Usually lighter than water, colorless or yellow, rapidly darkening and ultimately becoming resinoid, of marked and highly characteristic odor, readily combustible, nearly insoluble in water, freely soluble in alcohol, miscible in all proportions with carbon disulphide, fixed oils, turpentine, and petroleum spirit; they are, as a rule, unsaponified and not acted on by alkalies, but are destroyed by strong nitric or sulphuric acid.

They may be separated from their alcoholic solutions by addition of water or solution of sodium sulphate. They are very often adulterated with alcohol, chloroform, oil of turpentine, and fixed oils. Cheaper essential oils are often mixed with the more expensive. Essential oils are gradually affected by exposure to air, some oxygen being absorbed, while at the same time a peculiar resin is formed. This oxidizing action is attended by development of ozone. If a spray of one of these oils be discharged into a room where there is plenty of sunlight, enough ozone is generated to purify the air. It is likely that the oxidation and change of these oils is due to the presence of small traces of water. Mr. John Williams has obtained anhydrous essential oils, by means of apparatus in which the oils were distilled without presence of water.

328. **Anise oils:** the Saxon oil is the best, though the Russian is much liked. The official, *Oleum Anisi*, is colorless or yellowish, with the peculiar odor and taste of the seed. Its sp. gr. is 0.976 to 0.990, increasing by age. At 50°–59°F. it solidifies, but is fluid at 62°.6. It is soluble in an equal weight of alcohol.

329. **Bergamot:** *Oleum Bergamii*. It is of sweet, very agreeable odor, and of bitter, aromatic, pungent taste. In color the oil is pale green yellow. The reaction is slightly acid. It is soluble in alcohol.

330. **Cajuput:** this oil is transparent, with lively, penetrating, camphor-like odor, of green color, and warm, pungent taste. The green color is due to copper, sometimes to chlorophyll. It is met with of a greenish color, even when no copper is present. A specimen of Paris oil contained, according to Guibourt, 0.022 per cent. of copper. Cajuput oil is used in dentistry as a local application in odontalgia, and in neuralgia. *Oleum Cajuputi* is the official name.

331. **Caraway:** this oil, *Oleum Cari*, is somewhat viscid, pale yellow, becoming brownish on age, with odor of the fruit, and of aromatic, acrid, taste. It consists of two liquid oils, *carrene* and *carvol*, is of neutral reaction, and soluble in alcohol.

332. **Carvacrol:** obtained by treating caraway oil with iodine, and washing the product with caustic potash. Pure carvacrol is a viscid, colorless oil, nearly insoluble in water, of an odor like creasote, and of strong, acrid, persistent taste. It is lighter than water. It is antiseptic, disinfectant, and escharotic. It is used in dentistry locally in odontalgia, sensitive dentine, alveolar abscess, as an antiseptic, and in gargles. It dissolves Hill's Stopping and gutta percha.



333. **Cinnamon:** obtained by distillation from cinnamon, of a light yellow color when freshly prepared, becoming deeper by age and finally red. It has a pungent, hot taste. It is used in dentistry locally for relief of odontalgia.

334. **Cloves:** the oil of cloves contains a *cedrene* or hydrocarbon having the formula  $C_{15}H_{24}$ , and called *caryophyllin*. It contains other substances, as tannin, resin, and an oxygenized oil called *eugenol*, or *eugenic acid*. Oil of cloves is clear, and colorless when freshly prepared, but yellow and finally reddish brown on exposure. It has a hot, aromatic taste, and the odor of cloves. Good Zanzibar cloves yield about 18% of oil. Oil of cloves is used to disguise the odor of carbolic acid, creasote, etc. It is used in dentistry to relieve odontalgia.

335. **Eucalyptus:** the oil of eucalyptus is colorless or very pale yellowish, of characteristic, aromatic odor, and pungent, spicy, cooling taste, neutral in reaction, and soluble in alcohol. The official name is *Oleum Eucalypti*.

336. **Eugenol:**  $C_{10}H_{12}O_2$ , an oxidized oil, prepared by decomposing potassium eugenate with sulphuric acid. It is properly an acid and will be considered under the head of acids.

337. **Lavender:** this oil is obtained from the flowers of *Lavandula vera* and is of a pale-yellow color.

338. "**Listerine**": this substance contains among other things oil of *gaultheria*, a stimulant, volatile oil from the leaves of *Gaultheria procumbens*, first colorless, gradually becoming reddish, and one of the heaviest of the volatile oils. About 90 per cent. of the oil is composed of the so-called methyl salicylate,  $(CH_3)C_7H_5O_3$ . The formula of salicylic acid is  $C_7H_6O_3$ : that of methyl salicylate,  $C_7 \left\{ \begin{array}{c} H_5 \\ CH_3 \end{array} \right\} O_3$ .

239. **Mint:** oil of peppermint, *Oleum Menthae Piperitæ*, is of greenish yellow color, becoming reddish by age. It has a strong aromatic odor, and a warm, camphorous, pungent taste, succeeded by a sensation of coolness, when air is drawn into the mouth.

340. **Neroli:** the oil obtained from orange flowers is termed oil of neroli, and is a volatile oil of delightful odor.

341. **Pyrethrum:** the oil dissolved in ether is used in odontalgia. Pyrethrum or pellitory is a powerful local irritant.

342. **Rose:** this substance, known also as *attar* or *otto* of rose, is nearly colorless, concrete below  $80^\circ F.$ , liquid between  $84^\circ$  and  $86^\circ F.$  It has a powerful and diffusive odor, is slightly

soluble in alcohol, and of a slightly acid reaction. The official name is *Oleum Rosæ*. Probably *all* the oil of rose of the Turkish market is adulterated. It should, when slowly cooled to 50°F., deposit a crystalline substance, called a *stearopten*, free from oxygen.

343. **Sandalwood:** the oil of sandalwood, *Oleum Santali*, is yellow or pale yellowish in color, of a peculiar, strongly aromatic odor, and pungent, spicy taste. It is slightly acid in reaction, and readily soluble in alcohol.

344. **Sweet Almonds:** this oil is clear, colorless, or slightly greenish yellow, nearly inodorous, of bland, sweetish taste. It is but slightly soluble in alcohol, soluble in ether and chloroform.

345. **Star-anise:** this substance is not so expensive nor so valuable as oil of anise.

It is made from an evergreen tree in Japan and China, possesses properties analogous to those of the oil of anise, and is much used as a substitute for it.

346. **India-rubber and Gutta-percha:** caoutchouc or India rubber is the dried milky juice obtained from several trees growing in the tropics. When freshly obtained the juice is acid in reaction. It contains several hydrocarbons which are soluble in ether, benzole, carbon disulphide, chloroform, and turpentine, but insoluble in water, and in alcohol. It is hard and tough in the cold, softens on heating, becomes elastic, melts, and, on cooling, is soft and viscid. It combines directly with sulphur, forming **Vulcanized India rubber**; carbon disulphide is used to facilitate the union. Mixed with half its weight of sulphur, **Vulcanite** or **Ebonite** is formed.

Use in dentistry: for dental rubbers.

347. **Gutta-percha** resembles caoutchouc in chemical characters, and is the hardened milky juice of an Indian tree. It is harder than rubber, and less elastic but becomes quite soft in hot water, and can then be moulded. When purified it is brown-red, of a density of 0.979, electrified by friction, and is a very slow conductor of electricity. It has at ordinary temperatures considerable tenacity, is as strong as leather but less flexible. At 115°F., it is pasty and still very tenacious. At 103° and 104°F., it may be spread out into sheets, or drawn out into threads or tubes. Its suppleness and ductility diminish as the temperature is lowered, and it has not at any temperature the elastic extensibility of caoutchouc. Softened by heat, it may be worked by pressure into any shape. It is soluble in

carbon disulphide, benzene, chloroform, in hot oil of turpentine. It is insoluble in water, resists alkalis, hydrochloric acid, and hydrofluoric acid. *Gutta-percha alters*, and this fact must not be forgotten. If in thin sheets or threads, at a temperature of from  $77^{\circ}$  to  $86^{\circ}\text{F.}$ , it gradually becomes useless and gives off a pungent odor. The change is due to oxidation. Flagg alludes to the tendency of gutta-perchas to become "heat-rotted." In using them for dental purposes, it is important that only small portions be placed at a time on the warmer, and that they be very gradually heated. [The gutta-percha *filling materials* are divided by Flagg into three grades: 1: those sufficiently plastic to be worked at from  $140^{\circ}$  to  $200^{\circ}\text{F.}$ —*white gutta-perchas*; 2: those of medium grade—such as become plastic at temperatures varying from  $200^{\circ}$  to  $210^{\circ}\text{F.}$ ; 3: those of "high heat"—which do not become sufficiently plastic for manipulation at less than from  $216^{\circ}$  to  $230^{\circ}$ . These contain inorganic matter in addition to gutta-percha].

Use in dentistry: gutta-percha is used as a plastic filling material. It is an ingredient of Hill's stopping. Together with oxide of zinc, it is used as a filling material. According to Flagg, it is easy to raise the gutta-percha to any reasonable degree of temperature at which it becomes plastic, by simply increasing the relative quantity of inorganic admixture, but this very increase is destructive to the value of the gutta-percha.

348. **Artificial gutta-perchas** are now made. According to Zingler, copal resin, sulphur, petroleum, casein, tannin, and ammonia are the substances used in manufacture.

#### 349. **Camphor.**—

Theoretical constitution:  $\text{C}_{10}\text{H}_{16}\text{O}$ . It is sometimes classified among the aldehydes, but for convenience will be considered among the hydrocarbons on account of its oils. Camphor is a concrete substance derived from camphor-laurel tree; soft, tough cakes, easily powdered on addition of a little alcohol; translucent, strong fragrant odor, aromatic bitter cooling taste, volatile, inflammable; lighter than water; slightly soluble in water, but soluble in alcohol, ether, chloroform; dissolved in alcohol, forms *spirit of camphor*, from which it may be precipitated by water; dissolved in water containing a little alcohol and a little magnesium carbonate, forms *camphor-water*; boiled with bromine, forms *mono-bromated camphor*,  $\text{C}_{10}\text{H}_{15}\text{BrO}$ . Gum-camphor has a rotatory movement in water which is stopped by the least trace of fat. Camphor is a local irritant, stimulant, and powerful poison. *Camphora*.

*Spirit of camphor* is locally employed in dentistry to allay pain. It is an ingredient of celluloid base for artificial teeth. With ether it is used as a local anæsthetic.

Taken internally, it is poisonous although recovery from its effects are usual. 30 grains have killed a child, but 360 grains have been taken in a day without bad effects. The treatment is emetics and castor oil.

350. The official *Oleum Camphoræ* is made by heating camphor. It is a light reddish-brown fluid, of the taste and odor of camphor.

351. **Resins, Balsams, Gum-resins, etc.:** *resins* are oxidized terpenes, produced by the oxidation of the essential oils of plants. They are brittle, solid, transparent bodies, of no well marked odor or taste, soluble in alcohol, insoluble in water, combustible, yield a lather with alkalis.

Resins are employed in the manufacture of varnishes: *copal* resin is prepared by simple exudation.

352: **Guaiacum** resin is prepared by destructive distillation and in other ways, from a tree growing in South America and the West Indies. It comes in large, irregular, semi-transparent, brittle pieces, externally of an olive or deep green color, internally red. It has a slight balsamic odor, and leaves a hot acrid sensation in the mouth and throat. It is wholly soluble in alcohol, partly soluble in water.

353. **Gum-resins** are resins, mixed with gum, sugar, etc., in plants, and are insoluble in water, soluble in glycerine, turpentine, and strong alcohol. They are a mixture of several bodies, hence have not a definite chemical formula.

354. **Myrrh** is an exudation from an Arabian and African tree and is a gum-resin. It is of reddish-yellow or reddish-brown color, of fragrant, strong, peculiar odor, and bitter aromatic taste. It is translucent, pulverizable, and brittle. It should dissolve in fifteen times its weight of water, when rubbed up with an equal weight of sal-ammoniac. It has a resinous fracture, and makes a light yellowish powder. Inferior kinds are darker; less translucent, and less odorous. The resin of myrrh is called *myrrhic acid*. Myrrh forms an emulsion with water, and is soluble in alcohol and in ether. An old tincture of it has been shown to have an acid reaction. It is used in dentistry as a local application. The powder is also used in dentifrices.

355. **Gums** are non-volatile, colloid, almost tasteless bodies, occurring in the juices of plants. (See Carbohydrates.)

356. **Benzoïn:** benzoïn is a *ba'sam* and not a gum as often stated. It is obtained by incisions in the bark of a tall tree growing in Sumatra, Java, Borneo, and Siam. Two kinds are known: whitish *tears*, and brown or blackish *lumps*. It has a feeble, slightly aromatic taste, a fragrant odor, is soluble in alcohol and ether and is precipitated from alcoholic solution by water. It contains, amongst other things, a *resin* and *benzoic acid*.

357. **Balsams** are oleo-resins, containing *benzoic* or *cinnamic acids*. They are liquid, yield essential oils on distillation with water, and are viscous.

358. **Balsam of Tolu** is a semi-liquid balsam obtained from a tree growing near Carthagera. It is shining and translucent, of fragrant odor, reddish brown color, and warm, sweetish, pungent taste. It is inflammable. Its consistence becomes eventually hard and resin-like. It is entirely soluble in alcohol, and in essential oils, and yields its acid to boiling water. It contains a resin, volatile oil, and cinnamic acid.

359. **Canada Pitch** is the concrete juice of *Pinus Canadensis*, and contains a resin, and a volatile oil. It is found in the shops in hard, opaque, brittle masses, of a peculiar, weak odor, a dark, yellowish-brown color, and scarcely any taste.

360. **Amber:** this substance is a kind of fossil resin, obtained chiefly on the shores of the Baltic. By distillation it yields an oil, *Oleum Succini*, which at first is colorless, but gradually becomes brown; it is of strong, peculiar odor, and pungent, acrid taste. Oil of amber is soluble in alcohol. Amber yields also *succinic acid*.

361. **Sandarach:** sandarach is a substance composed of three resins, which are of different solubility in alcohol, ether and turpentine. Sandarach comes in tears, which are small, and of a pale yellow or brown color, and more or less transparent; they are dry, and brittle. Sandarach is inflammable, and melts on being heated. It is soluble in alcohol, ether, and warm oil of turpentine. It is used in dentistry, dissolved in alcohol, as a varnish.

The name sandarach is sometimes given to the disulphide of arsenic, which, however, has nothing to do with the resin sandarach, and should not be confused with it.

362. **Lac:** lac consists of resin, soluble coloring matter, lacin, wax, and salts. The resin is about 90 per cent. of lac. **Shell Lac** is one of the commercial varieties of lac, and is an exudate from several kinds of trees growing in the East



Indies; it is caused by punctures of insects. It is prepared from the crude lac by melting, straining, and pouring on a flat, smooth surface. Shellac comes in thin, shining, hard, brittle fragments, odorless, insoluble in water, but freely soluble in alcohol, more so in warm alcohol. It is used in dentistry as a varnish.

363. **Oleo-resins** are indefinite mixtures of an essential oil (terpene) with a resin; the latter may be obtained as a residue on distilling off the essential oil. They are in a liquid or semi-liquid state, and have the property of self-preservation.

364. **Aromatic series:** the general formula of this series is  $C_nH_{2n-6}$ .

The most important member of the series is *benzol* or *benzine*,  $C_6H_6$ , a substance obtained from coal tar by distillation. Its specific gravity is 0.876, and it can be told from benzine by its solvent action on pitch. Benzol is a hydride of the radical  $C_6H_5$ , which is found in carbolic acid. It is a colorless, limpid liquid, of peculiar odor suggesting coal gas, and burning taste. It is insoluble in water, but soluble in alcohol, ether, and naphtha. It is a solvent for fats, resins, sulphur, iodine, and phosphorus. It is combustible, burning with a smoky flame. The aniline colors are derived largely from benzol as a basis.

365. **Naphthalene:** naphthalene or naphthalin,  $C_{10}H_8$  or  $(C_{10}H_7)H$ , is a coal tar product, distilling from this substance between  $356^\circ F.$  and  $428^\circ$ . It crystallizes in large, white, rhombic plates, of silvery lustre, and characteristic odor, and of a biting, somewhat aromatic, taste. It melts at  $174.5^\circ F.$ , and boils at  $420^\circ$  to  $428^\circ$ . It volatilizes very sensibly, even at ordinary temperatures. It is inflammable, burning with a luminous and very smoky flame. Its specific gravity is 1.15. When melted, it dissolves sulphur, phosphorus, iodine, and indigo. It is insoluble in water, but soluble in hot alcohol, benzene, and ether, also in wood-spirit, chloroform, carbon disulphide, benzene, petroleum spirit, fixed and volatile oils. It is insoluble in alkaline, or dilute acid solutions, slightly soluble in concentrated acetic acid. It is an antiseptic substance, and when used as dressing, it should be thoroughly purified by recrystallization from alcohol, or by distillation with steam. It is not corrosive, and when *entirely* pure is odorless; it is, however, almost impossible to obtain it free from the characteristic odor, but the latter may be entirely overcome by adding a few drops of oil of bergamot to 4 oz. of



the naphthalin. In powdering naphthalin, addition of a little alcohol greatly facilitates the operation. As an antiseptic, the best results have been obtained from use of it in powdered form. Combinations of this substance with iodoform and with boric acid, should make valuable antiseptics. The naphthalin made in this country can be reduced to a moderately fine powder; the pure, imported naphthalin cannot be reduced to powder except when very cold. Attention should be paid to the fact that it is *inflammable*.

## CHAPTER X.

### ETHYL SERIES OF RADICALS; ALCOHOLS, AND CARBOHYDRATES.

366. Before considering the alcohols, it is well for the student to become familiar with the ethyl series of radicals.

TABLE 25—ETHYL SERIES OF RADICALS.

Radicals.	Hydrides of, or Marsh gases.	Oxides, or Ethers.	Hydrates, or Alcohols.
Methyl, $\text{CH}_3$	Methane, $\text{CH}_3\text{H}$ or $\text{CH}_4$ (marsh gas)	$(\text{CH}_3)_2\text{O}$ , or $\text{C}_2\text{H}_6\text{O}$ , methyl ether.	$\text{CH}_3\text{HO}$ , or $\text{CH}_4\text{O}$ , wood spirit, methyl alcohol.
Ethyl, $\text{C}_2\text{H}_5$	Ethane, $\text{C}_2\text{H}_5\text{H}$ or $\text{C}_2\text{H}_6$	$(\text{C}_2\text{H}_5)_2\text{O}$ , or $\text{C}_4\text{H}_{10}\text{O}$ , ether.	$\text{C}_2\text{H}_5\text{HO}$ , or $\text{C}_2\text{H}_6\text{O}$ , ordinary alcohol.
Propyl, $\text{C}_3\text{H}_7$	Propane, etc.	etc.	etc.
Butyl, $\text{C}_4\text{H}_9$	Butane, etc.	etc.	etc.
Amyl, $\text{C}_5\text{H}_{11}$	etc., etc.	etc.	$\text{C}_5\text{H}_{11}\text{HO}$ , or $\text{C}_5\text{H}_{12}\text{O}$ , amyl alcohol, fusel oil.

367. **Amyl nitrite:** this substance is the nitrite of the radical *amyl*; its formula is  $\text{C}_5\text{H}_{11}\text{NO}_2$ . Molecular weight, 117. It is made by heating equal volumes of purified amyl alcohol (fusel oil) and nitric acid, until the mixture boils. It is a yellowish, ethereal liquid, having the odor of over-ripe pears, and an aromatic taste. Its specific gravity is from 0.877 to 0.900. It is volatile and inflammable, soluble in alcohol; solution rapidly deteriorates. Several samples of amyl nitrite examined by Allen contained only 80 per cent of real amyl nitrite. It is used in dentistry as an antidote for chloroform, being administered by inhalation, and for relief of neuralgia, epileptic attacks during extraction of teeth, etc., etc.

*Toxicology:* in administering amyl nitrite by inhalation, care should be observed. The handkerchief should be withdrawn when the face flushes and the heart becomes excited.

368. **Ethyl bromide.**—

Synonyms: bromide of ethyl, hydrobromic ether, Ethyl Bromidum.

Theoretical constitution:  $C_2H_5Br$ , bromide of the radical ethyl, one molecule of ethyl and one atom of bromine, or two atoms of carbon, five of hydrogen, and one of bromine in its molecule. It is one of the so-called **haloid** ethers (see Ethers).

Preparation, properties, etc.: ethyl bromide is obtained by distilling potassium bromide, with alcohol, water, and sulphuric acid. The resulting product is redistilled with calcium chloride.

Ethyl bromide is a very volatile, colorless liquid of ethereal odor, strong, sweetish, pungent taste. It is heavier than water, and but slightly soluble in it; soluble in ether, and in alcohol. It often contains bromoform as an impurity, and, if it acquires a disagreeable odor, becomes brown on standing, or is inflammable or explosive, it is not fit for use.

Use in dentistry: ethyl bromide is an anæsthetic, producing complete anæsthesia in a few minutes, followed by recovery of consciousness in from one to two minutes after it is withdrawn.

Toxicology: several deaths from its use as anæsthetic have been reported.

369. **Alcohols:** alcohols may be regarded as substances derived from hydrocarbons, by replacing one or more hydrogen atoms by the radical hydroxyl, HO. Thus ethyl hydride,  $(C_2H_5)H$ , becomes ethyl alcohol,  $(C_2H_5)HO$ , by exchanging one atom of H for the radical HO. Alcohols are called monatomic, diatomic, or triatomic, according as HO replaces one, two, or three atoms of H in a hydrocarbon. Ordinary alcohol is a monatomic alcohol, diatomic alcohols are also called *glycols*, and of triatomic alcohols, glycerin is a notable example.

The alcohols are *hydrates*, resembling the inorganic hydrates, as, for example, potassium hydrate, KHO; common alcohol is ethyl hydrate,  $C_2H_5HO$ .

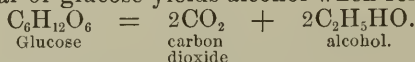
370. **Alcohol.**—

Synonyms: ethyl alcohol, common alcohol, ethyl hydrate, ethylic alcohol, Spirit of Wine.

Theoretical constitution:  $C_2H_5HO$ , hydrate of the radical ethyl, two atoms of carbon, six of hydrogen, and one of oxygen; formula sometimes written  $C_2H_6O$ . Molecular weight, 46. 24 parts by weight of carbon, 6 of hydrogen, and 16 of oxygen.

Preparation: alcohol is obtained by the fermentation of saccharine liquids, brought about by the growth of a microscopic plant called yeast.

Grape sugar or glucose yields alcohol when fermented:



The fermented liquid is distilled, and a dilute alcohol obtained; repeated distillations will finally give an alcohol containing about 14 per cent. of water. To obtain alcohol, free from water, the former must be mixed with half its weight of lime, and the alcohol distilled off from the mixture.

Properties: absolute alcohol containing no water is a transparent, mobile, volatile, colorless liquid of an agreeable, pungent odor, characteristic of itself, and a burning taste, boiling at 173° F., of a sp. gr., 0.794, and has never been solidified. It is neutral in reaction, inflammable, burning with a non-luminous flame, dissolves resins, essential oils, alkaline hydroxides, alkaloids, calcium chloride, mercuric chloride, and many other substances, but especially those rich in hydrogen. Mixed with water, a *contraction* of volume occurs, with production of heat. Its attraction for water is very great, and it absorbs moisture from the air, and abstracts it from membranes, tissues, etc. Shaken with pure, colorless sulphuric acid, it should not become colored (presence of fusel oil).

371. *Absolute alcohol*: commercial usage accepts as absolute, alcohol of not less than 99.5 to 99.7 per cent., of sp. gr. (at 60° F.) 0.7938, boiling at 172.4° F.

*Alcohol*, U. S. P., is 91 per cent. by weight of real alcohol, or 94 per cent. by volume, the rest being water.

*Alcohol dilutum* is 45.5 per cent. by weight, or 53 per cent. by volume.

*Spirit of wine (rectified spirit)* is 84 per cent. by weight.

*Proof-spirit* is 49 per cent.

*Spirits* are substances distilled from fermented liquors: brandy, whisky, rum, and gin. They contain from 35 to 45 per cent. of alcohol by volume, although some specimens run as high as 50 per cent., (brandy, rum) and 60 per cent., (whisky).

*Wines* contain from 6 to 25 per cent., sherry and port being the strongest.

*Beers* average 4 to 5 per cent., though some are very weak, containing only 1 per cent.

Use in dentistry: alcohol is used in dentistry for various

purposes: as styptic, antiseptic, obtunding agent, for drying cavities, in lotions, gargles, etc., etc.

Toxicology: the stomach pump should be used in cases of poisoning by alcohol, and, if the bladder is distended, use of the catheter is indicated. Cold affusion to the head, fresh air, ammonia, strong coffee are valuable, especially if the stupor be intense.

372. **Tinctures** are alcoholic solutions of the medicinal agents in plants, prepared by maceration, digestion, or percolation.

373. **Fluid Extracts:** these preparations are concentrated, and represent considerable drug-power in small bulk. Each Cubic centimetre represents a gram of the crude drug.

374. **Wood Spirit:** methyl alcohol, or wood spirit, is methyl hydrate,  $\text{CH}_3\text{HO}$ , called pyroligneous ether, pyroxylic spirit; wood naphtha is largely composed of it. It is made by distillation from wood. It is a liquid of spirituous odor, and inflammable.

375. **Fusel Oil** is amylic alcohol,  $\text{C}_5\text{H}_{11}\text{HO}$ , hydrate of the radical amyl, called also *potato spirit*. Fusel oil proper is a mixture of several alcohols, of which amylic alcohol is one. It is made from residues left in the still, after common alcohol is distilled off. It has a peculiar, irritating odor, and is very poisonous.

376. **Glycerine.**—

Theoretical constitution: this substance is a triatomic alcohol derived from propane,  $(\text{C}_3\text{H}_7)\text{H}$ , by substitution of  $3\text{HO}$  for *three* atoms of  $\text{H}$ . The formula for propane may be written  $\text{C}_3\text{H}_8$ ; take away three atoms of  $\text{H}$  and we have  $\text{C}_3\text{H}_5$ ; add  $3\text{HO}$  and there results  $\text{C}_3\text{H}_5\text{3HO}$ , or  $\text{C}_3\text{H}_8\text{O}_3$ . Glycerine is, then, the hydrate of a radical,  $\text{C}_3\text{H}_5$ , called *glyceryl*, *tritenyl* or *propenyl*. Hence the modern term for glycerine, namely, *tritenyl hydrate*.

Properties and uses: glycerine is obtained from fats by treatment with alkalis, **soap** being formed and glycerine liberated. The process is called **saponification**. Pure glycerine is a colorless, or light straw yellow, thick, syrupy liquid, unctuous, inodorous, of sharp, sweet taste; soluble in water, alcohol, and oils, but not in ether, and chloroform. It is valuable as a solvent for many medicinal substances, officinal solutions of which in glycerine are called **glycerites**. Glycerine is permanent and does not evaporate nor dry at any temperature. Officinal **Glycerinum** has a sp. gr. of 1.25. It dis-

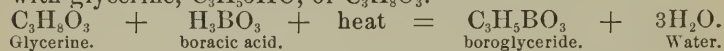
solves about fifty familiar substances used in medicine, among which are boric acid, borax, carbolic acid, creasote, potassium iodide, arsenic, alum, zinc salts, morphine salts.

Use in dentistry: its value in dentistry is as a solvent, and, when combined with other substances, as an emollient and solvent. Teeth lotions contain glycerine, as for example the following: tincture of quillaia, eau-de-cologne, water, borax, glycerine, with coloring. Glycerine is found to be of service in the process of vulcanizing India rubber, giving the latter the property of resisting oils and fats. Glycerine may be used to detect carbolic acid adulteration in creasote. (See Creasote.)

377. **Glycerites:** these are solutions of various substances in glycerine. Those most commonly used in dentistry are the glycerites of *carbolic acid*, *gallic acid*, *tannic acid*, *sodium borate*, *starch*, *thymol* and *pepsin*.

**Glycozone:**  $C_3H_8O_3 + O_2$ . Essentially hydrogen dioxide held in solution in glycerine. Said to be a powerful disinfectant, and bactericide.

378. **Boroglyceride:** boroglyceride,  $C_3H_5BO_3$  is *glyceryl borate*, or tritenylborate, made by heating boracic acid,  $H_3BO_3$ , with glycerine,  $C_3H_5_3HO$ , or  $C_3H_8O_3$ :



6 parts of boric acid in fine powder, and 9 of glycerine are heated together in a porcelain dish at  $302^\circ F.$ , stirring well until aqueous vapors cease to be given off, and a homogeneous, transparent, mass is formed, which becomes hard and tough on cooling. Care is taken not to heat the mixture too strongly, as that would render the product dark colored, (O and L). Boroglyceride is a colorless, tough, solid substance, soluble in water, and in alcohol, odorless, tasteless, not poisonous. It is used in dentistry as an antiseptic and, in combination with sodium sulphate, for bleaching teeth.

379. **Sodium glyceroborate:** this substance is made by heating equal parts of sodium borate with glycerine. Soluble, deliquescent, odorless, antiseptic.

380. **Calcium glyceroborate:** made by heating equal parts of calcium borate with glycerine. Soluble, deliquescent odorless, antiseptic.

381. **Creasote:** creasote, **Creasotum**, is a mixture of substances but consists chiefly of *creasol*,  $C_8H_{10}O_7$ , and *guaiacol*,  $C_7H_8O_2$ . It is a product of the distillation of wood-tar, occur-



ing in the lowest layer of distilled liquid. It is colorless, or faintly yellow, when fresh and pure, of sp. gr. 1.046, U. S. P., but usually varying from 1.040 to 1.090. It boils at 392°–410°F. It is of disagreeable, penetrating, smoky odor, and burning, caustic taste. It is soluble in 80 parts of cold water, and 24 of hot, and in all proportions in alcohol, ether, acetic acid, and carbon disulphide. Ignited it burns with a white, sooty flame. It forms a clear mixture with collodion, and precipitates solutions of gum, and of albumin. On growing old, it gradually becomes brownish in color. It may be distinguished from carbolic acid by not solidifying when cooled, by not coloring ferric chloride permanently, and by its lower boiling point.

A specimen of creasote, if pure, should leave no stain on paper, after being dropped on it, and volatilized by heat. Mixed with equal volume of collodion, it should not cause the latter to gelatinize.

*Creasote water*, Aqua Creasoti, is one fluidrachm of creasote to one pint of water. Solidified creasote is made from 10 parts of collodion to 15 of creasote.

Uses in dentistry: creasote is used as an obtunding agent, styptic, antiseptic, to counteract any acid in a tooth cavity, and to harden, and render imperishable, the contents of dental tubuli.

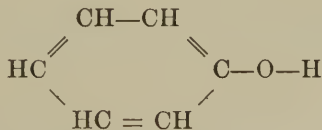
Toxicology: creasote is poisonous, in overdoses causing giddiness, obscurity of vision, depressed heart action, etc., etc.

The treatment consists in giving white of eggs, milk, wheat flour, and in administration of stimulants, as ammonia. An emetic should be first administered.

### 382. Phenyl alcohol or carbolic acid.—

Synonyms: phenol, phenylic alcohol, phenic acid. Official name, Acidum Carbolicum.

Theoretical constitution: carbolic "acid" is really an alcohol,  $C_6H_5HO$ , or hydrate of the radical phenyl,  $C_6H_5$ , graphically



It is by weight composed of 72 parts carbon, 6 of hydrogen, and 16 of oxygen. Molecular weight, 94.

Preparation: crude carbolic acid is obtained by distilling coal-tar, between the temperatures of 302°F. and 374°F.

Official carbolic acid is a pure phenol, obtained by distilling crude carbolic acid between  $338^{\circ}\text{F}$ . and  $365^{\circ}$ , separating from other products, and purifying by repeated crystallization.

Properties: carbolic acid, in the pure state, forms needle-shaped, colorless, interlacing crystals, neutral in reaction, having a characteristic, slightly aromatic odor, and pungent, caustic taste; the taste is sweetish when the acid is slightly diluted. It produces a white eschar on animal tissues, having a benumbing (caustic) effect. When pure, carbolic acid is permanent in the air, and not affected by light, but the ordinary acid usually changes to pink or red. Many theories have been proposed to account for the change: Kremel thinks the red color due to contact of the acid with many metals, or metallic oxides, and recommends the colorless acid to be kept in glass, free from lead, or in heavily tinned iron vessels, soldered with pure tin. The color does not in the least impair the medicinal value of the phenol.

Water dissolves 6 per cent. of phenol, according to Squibb. Five parts of phenol dissolve in 1 part of alcohol; 4 in 1 of ether; 3 in 1 of chloroform; 7 in 2 of glycerine; 4 in 7 of olive oil. It is also soluble in benzol, carbon disulphide, and fixed and volatile oils. Variations, in the melting and boiling points of phenol, are due to the greater or less proportions of water in it. Phenol is liquid at ordinary temperatures, when it contains 8 to 10 per cent. of water. The best grades in the market contain at least 2, and often over 4, per cent. of water. One volume of liquefied carbolic acid, containing 5 per cent. of water, forms, with 1 volume of glycerine, a clear mixture, which is not rendered turbid by the addition of 3 volumes of water (absence of creasote and cresylic acid). Carbolic acid should have no odor of creasote nor of volatile sulphur compounds. A clean, sweet, phenol odor is one of the best signs of good quality in carbolic acid. It should also be hard, and dry. An anhydrous acid, fused with from 4 to 5 per cent. of water, should, on cooling, become a solid mass of crystals again. The crystals become liquid at a temperature of from  $96.8^{\circ}\text{F}$ . to  $197.6^{\circ}$ . When reddened and liquefied, carbolic acid resembles creasote, but gives, dissolved in water, a permanent violet-blue with ferric chloride, while creasote gives a blue, which changes to green then to brown. The crystals may be prepared, for antiseptic use, by warming the bottle till they liquefy, then adding a few drops of glycerine. Carbolic acid is a valuable antiseptic. It coagulates albumin, and is poison-

ous. Death has followed external application of the acid, in large quantity, to extensive surfaces.

Use in dentistry: as an antiseptic, styptic, escharotic, obtunding agent, local anaesthetic, etc., etc.

Toxicology: carbolic acid is a powerful poison, being corrosive, and also producing coma, the acid being rapidly diffused and the odor of it, after death from poisoning, noticed everywhere throughout the body, even in the brain. The treatment is to give emetics, as, for example, apomorphine hydrochlorate subcutaneously, then raw eggs *ad libitum*, and magnesia suspended in a mixture of olive and castor oils; lime water with sugar is recommended. The coma must be treated as in cases of opium poisoning, by artificial respiration, galvanism, etc., etc. Chances of recovery from poisonous doses of the acid are not good. The urine should be watched, when carbolic acid is being used, and if it darkens, it is a sign that too much of the agent is being used.

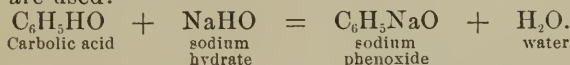
### 383. Various preparations containing carbolic acid.—

Robinson's remedy is equal parts of caustic potash (potassium hydrate) and carbolic acid mixed, by trituration, until a paste is formed.

Chloral hydrate and carbolic acid, when mixed in proportion of 1 part of chloral to 1.7 parts of the acid, liquefy, and the liquid is soluble in water in all proportions.

384. **Phenates:** carbolic acid, with solutions of the alkalies, forms soluble compounds called phenates or phenylates, which are capable of dissolving large quantities of phenol.

385. **Phenol sodique or sodium phenate:** this substance,  $C_6H_5NaO$ , is also called carbonate of sodium, sodium phenoxide, Sodæ Phenas. It is made by the direct combination of carbolic acid with sodium oxide; caustic soda and a little water are used:



Sodium phenate occurs in form of acicular crystals of light pinkish color, liquefied by heat. It is used in dentistry as an astringent, styptic, disinfectant, etc., etc. It is freely soluble in water.

386. **Phenol terchloride:** this substance is of Russian introduction, and is extemporaneously prepared by mixing one part of a four per cent. solution of carbolic acid with five parts of a saturated solution of chlorinated lime; the filtrate is said to be 25 times more powerful than carbolic acid. Ac-

cording to some it is made by passing a stream of chlorine gas through pure melted carbolic acid, until a violet color is seen.

387. **Aseptol:** orthophenol-sulphate,  $C_6H_4(HO)SO_2(HO)_2$  is a syrupy, brown fluid of aromatic odor, soluble in alcohol, glycerine, and water and not irritating in 10 per cent. solutions. It is an antiseptic, equal in power to carbolic acid.

Dental uses: **phenol terchloride** is used as an antiseptic and disinfectant. It is combined with iodoform, and used as a capping and filling material, incorporated with decalcified dead bone.

**Aseptol** is a valuable antiseptic according to D. F. Hueppe, and doubtless will partially replace carbolic acid as a disinfectant and antiseptic. It would seem destined to be of value in dentistry in treatment of fetor of the breath.

388. **Sulphocarbolic acid** and **sulphocarbolates:** sulphocarbolic acid, or orthophenol sulphonic acid, is formed when one part, by weight, of strong sulphuric acid is mixed with one part of crystallized carbolic acid. Its formula is  $HC_6H_5SO_4$ . Its salts are sulphocarbolates, formed usually by dissolving carbonates of the various metals in sulphocarbolic acid.

389. **Sulpho-carbolate of sodium:** made from crystallized phenol, 10 parts; sulphuric acid, 12 parts; barium carbonate, 20 parts; sodium carbonate, 34 parts. Official name, Sodii Sulpho-Carbolas. Formula,  $NaC_6H_5SO_4, 2H_2O = 232$ . Occurs in colorless, transparent, rhombic prisms, permanent in air, odorless, or nearly so, of cooling, saline, somewhat bitter taste, and neutral reaction, soluble in 5 parts water, and 132 of alcohol.

**Sulpho-carbolate of zinc:** Zinci Sulpho-Carbolas. Formula,  $Zn (C_6H_5SO_4)_2, 8H_2O = 554.9$ . Occurs in thin colorless-plates, soluble in water and in alcohol, crystallizes more readily from a solution slightly acidulated with sulphuric acid. (O. & L). The sulphocarbolates of *potassium* and of *magnesium* are sometimes used.

390. **Phenol-camphor** is best obtained by heating crystallized carbolic acid (phenol) until it fuses, and then gradually adding camphor; a clear liquid is obtained which is characteristic on account of its permanency. In preparing this substance, use equal parts of camphor and carbolic acid: it remains liquid for an indefinite time, and does not solidify on being subjected to the low temperature of a frigorific mixture of snow and sodium chloride. Phenol-camphor  $[C_8H_{11}O(?)]$  is

a colorless, refractive liquid, possessing the fragrant odor of camphor, entirely extinguishing the one of carbolic acid, and has a sweetish, camphoraceous, but biting taste, not as caustic as that of carbolic acid, somewhat benumbing the tongue. It is soluble in alcohol, ether, chloroform and ethereal oils, but insoluble in glycerine and water, being heavier than the latter. When ignited it burns with a smoky flame. There is reason to believe that this is a chemical compound. Dr. Schæffer has used phenol-camphor as a local anæsthetic in tooth-ache, introducing it on cotton into the cavity of a carious tooth, with good success; and can speak of it favorably as a local anæsthetic in the ingrowing of the toe-nails. He has used it also in combination in certain eruptions due to cryptogamic causes. This substance can be likewise used as antiseptic. It mixes well with paraffin, cosmoline, and a number of oils. In impregnating cotton gauze (antiseptic gauze), phenol-camphor may be used as a substitute for carbolic acid. Phenol-camphor is less irritating, less caustic than carbolic acid, and has also the advantage of possessing a pleasant odor.

391. **Picric acid**, or trinitrophenol, is formed when carbolic acid is acted on by nitric. It is very bitter. Its formula is  $C_6H_3(NO_2)_3HO$ . It occurs in lemon yellow crystals, soluble in water and alcohol.

392. **Resorcin**: this substance has for its formula  $C_6H_5NO_2$ , or better  $C_6H_4 \begin{cases} NO \\ HO \end{cases}$ , from which it will be seen that it differs from carbolic acid, in that the radical NO has been substituted for one atom of hydrogen, carbolic acid being  $C_6H_5HO$ , and resorcin,  $C_6H_4NOHO$ .

It is made from gum-resins, such as galbanum, extract of sapin wood, or Brazil wood, by fusing with caustic potash. It occurs in the form of colorless crystals, of somewhat sweetish, slightly pungent taste, very soluble in water, less so in alcohol, ether, glycerine and vaseline, insoluble in chloroform, and carbon disulphide. It is not so irritating as carbolic acid. It is said to be a disinfectant, and local anæsthetic.

It is used in dentistry as an antiseptic. Strong solutions are caustic, but dilute ones merely astringent.

393. **Thymol**: formula  $C_{10}H_{14}O$ . There are many thymols. The one found in essence of wild thyme is used in dentistry, and may be procured by treating the essence with potassium hydrate; agreeable smelling liquid, insoluble in water, antiseptic. Freely soluble in alcohol. Used in dentistry, combined with glycerine, as an antiseptic.



394. **Menthol:** this substance is really *menthyl alcohol*,  $C_{10}H_{20}O$ , and is found in peppermint oil. It is a white, crystalline solid of but slight peppermint-oil odor when pure, soluble in alcohol and in the essential oils. It has been called peppermint camphor, Japanese camphor, peppermint stearescence, and stearoptene of peppermint, but, in constitution, is a monatomic alcohol. It is an antiseptic, and local anæsthetic. It is used in dentistry as an obtunding agent, local anæsthetic, and antiseptic. Care must be taken in applying it, as small doses, taken internally, have been known to produce vomiting.

395. **Eucalyptol:**  $C_{12}H_{20}O$ , liquid, colorless, of aromatic odor. It is derived from the leaves of *Eucalyptus globulus*, and is sometimes called eucalyptus oil. It is but slightly soluble in water, but is soluble in alcohol. It is an efficient antiseptic, and is used in dentistry on this account, and as an astringent, styptic, and local anæsthetic. It has solvent action on gutta percha. The purest eucalyptol is as clear as water, of specific gravity 0.910 to 0.920 at  $60^{\circ}F.$ , and boils between  $338^{\circ}F.$ , and  $343^{\circ}$ . There is in the market an eucalyptus oil which differs from the genuine eucalyptol; 90 per cent. alcohol makes a clear solution of eucalyptol, while the eucalyptus oil is but slightly soluble in it.

396. **Carbohydrates:** these are substances containing six atoms of carbon, or a multiple of six, and twice as many atoms of hydrogen as of oxygen. They closely resemble the alcohols, and may be divided into three classes: saccharoses, glucoses, and amyloses.

Of the saccharoses, cane sugar and milk sugar are important.

397. **Cane sugar:** saccharose, cane sugar, beet sugar,  $C_{12}H_{22}O_{11}$ , does not occur in the body; white, inodorous, very sweet. Cold water dissolves three times its weight; insoluble in alcohol. Converted by ferments first into mixture of glucose and lævulose, called *invert* sugar. Blackens with  $H_2SO_4$ . (Glucose unites with the acid and does not blacken). Cane sugar occurs in the juices of many plants, fruits, flowers, and in honey. It is found also in the juice of the sugar cane, in sorghum, beet-root, and sugar-maple.

398. **Milk-sugar:** lactose, sugar of milk, *saccharum lactis*,  $C_{12}H_{22}O_{11}H_2O$ , one of the constituents of milk of mammals; rarely found in vegetables. Coagulate skimmed milk with a little acetic acid, heat, filter, concentrate filtrate by evaporation, let crystallize, dissolve in boiling water and re-crystal-



lize. Odorless, white, hard, occurs in four-sided, rhombic prisms; taste faintly sweet, gritty between the teeth; soluble in seven parts cold water, one of boiling; insoluble in even sixty per cent. alcohol; not charred by  $\text{H}_2\text{SO}_4$ ; not directly fermented by yeast, but easily when cheese is added; does not form a syrup with water.

399. **Glucose**,  $\text{C}_6\text{H}_{12}\text{O}_6$ , is raisin sugar and grape sugar; it is also called dextrose and starch sugar. It is found in vegetables, fruits, and honey. Is white, inodorous, and soluble in its own weight of water. Only one third as sweet as cane sugar. Ferments directly with yeast, and in contact with decaying animal matter. Made on a large scale from corn starch, by boiling with dilute sulphuric acid, neutralizing with lime, draining off clear syrup, evaporating, and allowing to crystallize. Fermented, it decomposes into alcohol and carbonic acid.

400. The **amyloses** are starch, dextrine, gum, etc. **Starch** is found in grains of cereals and in potatoes; food of plants becoming sugar as they grow; insoluble in cold water, alcohol and ether; in boiling water it becomes gelatinous, but does not dissolve; heated dry it becomes dextrine, which is converted into glucose by action of diastase (a ferment found in cross-spined barley).

**Dextrin**: is an amorphous, yellowish-white, soluble substance; does not give blue coloration with iodine; basis of mucilage. Reduces alkaline copper solutions.

The formula for starch is probably some multiple of  $\text{C}_6\text{H}_{10}\text{O}_5$ . That of dextrine,  $\text{C}_6\text{H}_{10}\text{O}_5$ .

401. **Honey**: honey is practically a strong solution of dextro-glucose, and lævo-glucose in water. Analyses show that the lævulose and dextrose are nearly equal in amount. Fictitious honey is sometimes manufactured from glucose and flavoring materials; the presence of glucose, as an adulteration, is indicated by increased proportion of ash, and by the presence of a notable amount of calcium sulphate. *Honeys* are preparations of medicinal substances in honey, the clarified article being used. *Honey of sodium borate* contains a drachm of borax to the ounce of clarified honey.

402. **Gums**: these bodies are probably carbohydrates. They are a peculiar class of bodies, occurring in the juices of plants. They are entirely non-volatile, of little or no taste, uncrystallizable, and colloidal. They are either soluble in water, or swell up in contact with it. They are not capable of being fermented by yeast and are insoluble in alcohol.

403. **Gum Arabic** is the dried exudation from the bark of various species of *Acacie*. Picked Turkey gum is the finest, and occurs in colorless lumps, full of minute cracks. It consists, chiefly, of calcium arabate, or the calcium salt of arabic or gummic acid. It is inodorous, of feeble, slightly sweetish taste, and with water forms a viscid mixture, called a *mucilage*. The mucilage is used in dentistry as an emollient.

404. **Gum Tragacanth**: this is a white, or yellowish, substance which is only very slightly soluble in water, and swells up in it. It contains usually about 60 per cent. of a substance which yields *pectic acid*, also 8 or 10 per cent. of soluble gum, probably *arabin*, the rest being starch, cellulose, water, etc., etc.

405. **Cellulose**:  $C_6H_{10}O_5$ , is an isomer of starch, and constitutes the essential part of the solid framework or cellular tissue of plants. Swedish filter-paper, linen rags, and cotton-wool are more or less pure cellulose.

*Absorbent cotton*: consists essentially of cellulose.

406. **Collodion** is made by dissolving 4 parts of pyroxylin in a mixture of 26 parts alcohol, and 70 of ether. Pyroxylin is prepared by steeping cotton in a mixture of nitric and sulphuric acids.

*Flexible collodion* is collodion, to which 5 per cent. of turpentine and 3 per cent. of castor oil have been added.

*Cantharidal collodion* is made from powdered cantharides, and flexible collodion, with sometimes addition of a little Venice turpentine, to prevent contraction on drying.

*Iodized collodion* is a solution of iodine in collodion, 20 grains to the ounce. *Iodoform collodion* contains 1 part iodoform to 15 of collodion.

*Styptic collodion* contains 20 per cent. of tannic acid.

Collodion is a colorless liquid, of ethereal odor, and very inflammable; exposed to the air, it rapidly evaporates, leaving a thin, transparent, strongly contractile film of dinitro-cellulose, which is insoluble in water or in alcohol. It is precipitated by carbolic acid. Collodion is used in dentistry as a local application in alveolar abscesses, in combination with other agents in odontalgia, on cotton as temporary filling, as a styptic, etc., etc. A colored preparation of collodion is used to coat the surface of plaster models. Collodion, when thickened, may be rendered thinner, by dilution with a solution of 1 part alcohol in 3 parts ether.

*Cantharidal collodion* is used as a counter-irritant in dental periostitis. A German preparation of cantharidal collodion

has been proposed by Dieterich to contain—in 1,900 parts of collodion—3 parts of cantharidin, and 97 of oil of rape. The German blistering collodion is stronger than the U. S.

407. **Celluloid:** pyroxylin is reduced to a pulp, mixed with camphor, oxide of zinc, and vermilion, subjected to immense pressure, and seasoned. Celluloid cannot be permanently colored by aniline dyes, and permanent or fast colors should be used for coloring purposes.

## CHAPTER XI.

ETHERS, ALDEHYDES, KETONES, GLUCOSIDES, FATS, WAXES, ETC.

408. **Ethers** are derived, theoretically, by replacing the hydrogen atoms in water by hydrocarbon radicals; they are, therefore, *oxides*. Ethers are either *simple* or *mixed*, according as the hydrocarbon radicals are alike or different; thus common ether is a *simple* ether,  $(C_2H_5)_2O$ , that is,  $C_2H_5-O-C_2H_5$ , while methyl-ethylic ether is a *mixed* ether,  $C_3H_8O$ , that is,  $CH_3-O-C_2H_5$ .

*Haloid* ethers are bromides, chlorides, etc., of the hydrocarbon radicals: thus, hydrobromic ether is  $C_2H_5Br$ , or ethyl bromide. *Compound ethers* are salts of the hydrocarbon radicals as, for example: methyl acetate,  $CH_3(C_2H_3O_2)$ , or  $CH_3-O-C_2H_3O$ . *Fats* are compound ethers, in which the hydrocarbon radical is *glyceryl*—in almost all cases; thus, stearin is stearate of glyceryl,  $C_3H_5(C_{18}H_{35}O_2)_3$ .

### 409. Common Ether.—

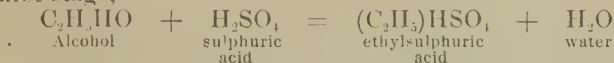
Synonyms: ethyl ether, ethyl oxide, vinic ether, sulphuric ether, *Æther*, *Æther Sulphuricus*.

Theoretical constitution:  $(C_2H_5)_2O$ , or ethyl oxide, derived from  $H_2O$  by substituting  $C_2H_5$  for each atom of hydrogen; contains 4 atoms of carbon, 10 of hydrogen, and 1 of oxygen in its formula; by weight, 48 parts carbon, 10 of hydrogen, and 16 of oxygen. Molecular weight, 74. Graphic formula,  $C_2H_5-O-C_2H_5$ .

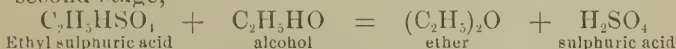
Preparation: sulphuric acid is used to etherize alcohol, hence the name sulphuric ether. There is not, however, any sulphuric acid in pure ether. 1 part of strong sulphuric acid and 6 or 7 of commercial alcohol are heated to  $266^\circ F.$ , in a retort, and then alcohol is run in, slowly, by means of a funnel, while the temperature is kept between  $266^\circ F.$ , and  $284^\circ$ , and the mixture distilled. The liquid resulting from the dis-

tillation contains on its surface crude ether, which, purified by washing, dried, and redistilled, is ready for the market. The reactions are as follows:

first stage,



second stage,



The second equation shows that the acid is obtained again, hence a small quantity of sulphuric acid can be used to convert considerable alcohol into ether. Ether for anaesthetic purposes is further purified by shaking with water, and contact with lime, and chloride of lime.

Properties: pure ether is a mobile, and very volatile liquid, colorless, limpid, and inflammable, of sweetish, characteristic odor and burning taste. It should be kept in bottles closed by ground-glass stoppers, as it readily evaporates. It is soluble in 10 volumes of water, and in alcohol in all proportions. It dissolves oils, resins, many organic bodies, iodine, bromine, sulphur, phosphorus, and mercuric chloride. Ether should not only be kept from the air, but also from the light. Its vapor is  $2\frac{1}{2}$  times as heavy as air, therefore flows, and will inflame from contiguous flame. The sp. gr. of ether is variously given as 0.720, 0.736, and 0.713; that of stronger ether, Aether Fortior, is 0.728. The latter contains about 94 per cent. of pure ether, and 6 per cent. of alcohol. Ether used for anæsthetic purposes should not affect blue litmus, should leave no residue when evaporated on a watch glass, should boil when a test tube of it is held in the hand, and should not impart a blue color to ignited copper sulphate.

Use in dentistry: ether is used as an anæsthetic, both by inhalation, and locally; also as an anodyne, and in various conditions, as aphthæ, etc.

Toxicology: the treatment, in cases where dangerous symptoms appear, is to cease administering the ether at once, and, if the breathing begins to fail, to pull out the tongue, to apply electricity, the poles being placed over the phrenic nerves (on a line with the 4th cervical vertebra) and to try artificial respiration. In administering ether, the breathing should be watched.

410. **Methyl Ether:** the formula for this substance is  $(\text{CH}_3)_2\text{O}$ , and it is made by digesting methyl alcohol with

strong sulphuric acid. Dissolved in ethylic ether it is called *methyl ethylic ether*, and has been used as an anæsthetic in dental operations.

411. **Nitrous ether** is ethyl nitrite,  $C_2H_5NO_2$ . Dissolved in alcohol, it is commonly known as *sweet spirit of nitre*. It is a volatile, inflammable, liquid of pale yellow color, slightly inclining to green, of fragrant, ethereal odor, and sharp, burning taste. It contains five per cent. of nitrous ether, and becomes strongly acid by age. The officinal name is *Spiritus Ætheris Nitrosi*. Fatal results have followed inhalation of it.

412. **Chloroform.**—

Synonyms: trichlormethane, dichlor-methyl chloride, formyl terchloride.

Theoretical constitution:  $CHCl_3$ , or methane,  $CH_4$ , in which three atoms of hydrogen have been replaced by one of chlorine. Chloroform has, in its molecule, one atom of carbon, one of hydrogen, and three of chlorine; by weight, 12 parts carbon, 1 of hydrogen, and 103.2 of chlorine. Molecular weight, 119.2.

Preparation: commercial chloroform is usually made by the action of bleaching-powder on alcohol; in 24 parts of water 6 parts of bleaching powder are dissolved, the mixture strained into a retort, heated to  $104^\circ F.$ , and one part of strong alcohol added. The mixture is then distilled. Bleaching powder is chiefly calcium hypochlorite, which, with alcohol, yields, on distillation, chloroform, calcium formate, calcium chloride and water, through various intermediate stages.

Chloroform for anæsthetic purposes, *purified chloroform*, U. S. P., is prepared from the commercial by mixing with sulphuric acid, agitating, drawing off the chloroform, treating with sodium carbonate, and distilling over calcium oxide.

In a new process for making chloroform, alcohol is said to be dispensed with, and the chloroform made by distillation of wood and subsequent treatment of the distillate. Chloroform is also made from chloral hydrate, and by electrolysis from chlorides of the alkalis in presence of alcohol, aldehyde, or acetone.

Properties: chloroform is a mobile, colorless, volatile liquid of bland, peculiar, sweetish, ethereal odor, and hot, aromatic, saccharine taste. Specific gravity of the purified is 1.5022, and it boils at  $142^\circ F.$  The officinal chloroform of the U. S. Pharmacopœa contains a little alcohol, and its sp. gr. is 1.488. It is not miscible in water, but is freely soluble in alco-



hol and ether. It dissolves a large number of substances, among them camphor, fixed and volatile oils, many resins, fats, caoutchouc, sulphur, phosphorus, iodine, bromine, and many alkaloids.

Purified chloroform should not affect litmus paper, nor color green a mixture of chromic and sulphuric acids. Sulphuric acid should not color it brown, nor should potassium hydrate. Allowed to evaporate on the hand, no foreign odor should be noticed.

It is said not to be inflammable, but is combustible, burning with a dull, smoky flame on application of a naked flame to it.

*Spirit of chloroform* contains an ounce of chloroform in two ounces of dilute alcohol.

Uses in dentistry: chloroform in dental practice is used as an anæsthetic, both general and local, though, for the latter purpose, usually combined with other agents; as an anodyne, and antispasmodic. It is also an antiseptic and hemostatic. Applied to the skin, it acts as an irritant and vesicant, if evaporation is retarded.

Toxicology: deaths following administration of chloroform have been quite frequent. Paralysis of the heart and, in some cases, exclusion of air from the lungs are the causes of death. In administering it, some air should be admitted along with it. It should never be administered to persons suffering from diseases of the heart or kidneys. At the slightest symptom of heart failure during administration of chloroform, the patient should be placed in a recumbent position, cold affusions applied, and artificial respiration, together with electricity, be resorted to. Inhalations of from three to five drops of amyl nitrite have been recommended.

413. **Iodoform:** this substance is  $\text{CHI}_3$ , and similar in theoretical constitution to chloroform, except that it contains iodine instead of chlorine. It may be made by acting on alcohol, aldehyde, and many other substances with iodine, and potassium carbonate or hydrate. It is usually prepared by heating together an aqueous solution of potassium carbonate, iodine, and alcohol, until the brown color of the iodine has disappeared. It occurs in small, lemon-yellow, lustrous crystals of an odor not so bad at first, but soon becoming unsupportable. It melts at  $248^\circ \text{F.}$ , and volatilizes gradually at ordinary temperatures. It is nearly insoluble in water and acids, but soluble in alcohol, ether, chloroform, bisulphide of carbon, fixed and volatile oils. It is not, however, so easy to

dissolve it, as many of the books would lead us to infer. It is neutral in reaction. Iodoform is not an escharotic, and is an antiseptic, disinfectant, and anæsthetic. It is now made by electrolysis from iodide of potassium dissolved in alcohol, through which a stream of carbonic acid is constantly passed. Iodoform is decomposed by sunlight. It loses 0.016 per cent. an hour, exposed in a thin layer, to the air.

Use in dentistry: it is used as an antiseptic, and anodyne; dissolved in oil of turpentine, it is said to be a germicide. It acts chemically, by allowing escape of free iodine, and also mechanically, favoring cicatrization. In dentistry, iodoform is combined with numerous agents, among them eucalyptol, arsenic, creasote, carbolic acid, camphor, etc., etc.

The odor of iodoform may be disguised by mixing 1 part of cumarin with 25 of iodoform. The odor may be removed from the hands, by washing them in an aqueous solution of tannic acid. A French antiseptic dressing containing iodoform is composed of equal parts of powdered iodoform, cinchona, benzoin, and magnesium carbonate, the latter being saturated with eucalyptol. Acetate of potassium should be given in cases of poisoning.

414. **Iodol:** this substance is tetra-iodo-pyrrol, and is made from pyrrol, a product of the destructive distillation of proteids.

415. **Aldehydes:** aldehydes lie midway between alcohols and organic acids; they have two less atoms of hydrogen than the corresponding alcohol.

**Paraldehyde** ( $C_2H_3HO$ )<sub>3</sub> or  $C_6H_{12}O_3$ , is used as a substitute for morphine, and is a liquid.

416. **Chloral hydrate.**—

**Chloral** is prepared by passing dry chlorine into absolute alcohol, until saturated, then adding sulphuric acid and distilling. The chloral thus obtained is a colorless liquid; if, now, this liquid be treated with a small quantity of water, it becomes a solid,  $C_2Cl_3HO.H_2O$ , which is the well-known **chloral hydrate**. The latter is a colorless, transparent, crystalline solid, of aromatic, pungent odor and taste, soluble in water, very soluble in alcohol, ether, glycerine, fixed and volatile oils, neutral in reaction, melting at 136.4°F., and boiling at 203°. It has a bitter, caustic taste; it liquefies when mixed with carbolic acid or camphor. It volatilizes slowly at ordinary temperatures. It is decomposed by weak alkalies into chloroform, and a formate of the alkali metal; this change was

thought to take place in the blood when chloral was taken internally, but recent investigations fail to support the theory.

In preparing chloral, 5 per cent. of ferric chloride is added by some to the alcohol, before the chlorine gas is introduced.

Use in dentistry: chloral hydrate is used in dentistry locally, for relief of odontalgia, etc. It is an antiseptic, and local anæsthetic, especially when combined with other agents. Chloral hydrate is familiarly termed "chloral".

Toxicology: the treatment, in cases of poisoning, consists of use of the stomach pump, and maintenance of respiration.

417. **Croton-chloral hydrate** is, chemically speaking, *butyl-chloral hydrate*. Its formula is  $C_4H_5Cl_3O.H_2O$ . It is made by passing dry chlorine through aldehyde cooled to  $14^{\circ}F$ . Butyl-chloral is obtained, and, on addition of water, butyl-chloral-hydrate. It occurs in the form of crystalline, micaceous scales, of pungent odor, sparingly soluble in water, readily in alcohol, and in hot water, nearly insoluble in chloroform.

418. **Ketones:** these substances are consequent on the first action of oxidizing agents on secondary alcohols, just as primary alcohols yield aldehyde when oxidized. Secondary alcohols contain the group of atoms  $CHHO$ , instead of  $CH_2HO$ , in ordinary alcohol.

Salicyl-resorcin-ketone is used in dentistry. It is an antiseptic substance, soluble in alcohol and in glycerine, non-poisonous, and not disagreeable to the taste.

419. **Glucosides:** these bodies are regarded as ethers of glucose. Those used in dentistry are tannin, and gallic acid.

*Tannin*, tannic acid, gallotannic acid, is  $C_{14}H_{10}O_9$  with  $C_{17}H_{22}O_{17}$ . The tannic acid used in dentistry is obtained from powdered galls. It forms light-yellow, amorphous scales, of faint characteristic odor, and strongly astringent taste, easily soluble in water, and diluted acids. Tannin unites with albumin, gelatin, etc., forming insoluble compounds. In the blood, it absorbs oxygen and becomes gallic acid. It is an active astringent and styptic, and is a valuable agent in dentistry as a local application in many disorders, as mercurial stomatitis, hemorrhage after extraction, etc. It is sometimes used dissolved in glycerine, *Glyceritum Acidi Tannici*, and also in the preparation known as **styptic colloid**, which is a saturated solution of tannin and gun cotton.

420. **Gallic acid**,  $11C_7H_5O_3$ , or  $C_6H_2(HO)_3CO_2H$ , is obtained by exposing moistened galls to the air, for six weeks. A peculiar kind of fermentation takes place, and the tannic acid

of the galls is converted into gallic acid. Gallic acid is a white solid, occurring in long silky needles. It has an astringent, slightly acid taste, and is acid in reaction. It is not readily soluble in cold water; it is soluble in three parts of boiling water, in alcohol, and in ether. It is used in dentistry in form of a gargle: as astringent, antiseptic, and styptic.

421. **Fats and fixed oils:** these substances, as has been stated before, are compound ethers of glyceryl. Some are liquid, and others solid. *Stearin* is the constituent of the more solid fats, *palmitin* of mutton, lard, and human fat; *olein*, is the fluid constituent of fats and oils. Fats and oils, when treated with hot alkalies or with superheated steam, are saponified, as the term is, stearates, palmitates, and oleates of the alkalies being formed (**soap**) and glycerine.

422. *Cacao butter* is a concrete oil from the kernels of the fruit of *Theobroma Cacao*.

423. *Waxes* belong to the spermaceti group of oils. They do not form glycerine when saponified.

424. *Bees-wax* is the material of which the honey-comb of bees is composed. It occurs as a compact, tough, solid substance of a yellow or brown color, almost tasteless, but of characteristic aromatic odor. It is not greasy to the touch. On exposure to air and light in thin slices, it becomes decolorized. It may be bleached by nitric acid. It is insoluble in water, but soluble in the fixed oils, oil of turpentine, benzol, ether, and carbon disulphide. It is difficultly soluble in alcohol. Its specific gravity is from 0.959 to 0.969.

425. The yellow wax is **Cera Flava**; bleached it is called **Cera Alba**, or white wax. The best method of bleaching is exposure to moisture and the rays of the sun. A new process is, first, to melt together 8 parts of yellow wax and 1 to 1½ parts of rectified oil of turpentine, and then expose to air, etc. Grain wax may be bleached by dioxide of hydrogen. Other chemicals cannot be used as they change its constitution.

426. **Croton Oil:** this oil belongs to the Castor Oil Group of oils, distinguished by their very high specific gravity, and viscosity. They are readily soluble in alcohol, and are strongly purgative. Both castor oil and croton oil are miscible with glacial acetic acid in all proportions. In drying character, they resemble the oils of the Cotton Seed Oil Group.

It produces pustules, when applied to the skin, and is valuable as a counter-irritant.

**Toxicology:** in overdoses it has frequently proved fatal.

## CHAPTER XII.

### ORGANIC ACIDS AND SALTS.

427. Organic acids may be deemed as built upon the water type, half the hydrogen, in one or more molecules of water, being replaced by a compound organic radical, always containing oxygen; for example, water is  $\text{H}_2\text{O}$  or  $\text{H}-\text{O}-\text{H}$ : replace half the hydrogen, that is, one atom, by  $\text{C}_2\text{H}_3\text{O}$ , a compound organic radical containing oxygen, and we have  $\text{H}-\text{O}-\text{C}_2\text{H}_3\text{O}$  or  $\text{HC}_2\text{H}_3\text{O}_2$ , acetic acid. It will be noticed that this formula is the same as that of ethyl aldehyde, plus one atom of oxygen. Alcohol, aldehyde, and acetic acid resemble one another in a certain way. Thus, the formula for ethyl alcohol is  $\text{C}_2\text{H}_6\text{O}$ , that of aldehyde,  $\text{C}_2\text{H}_4\text{O}$ , or alcohol minus two atoms of hydrogen, and that of acetic acid  $\text{C}_2\text{H}_4\text{O}_2$ , or aldehyde plus one atom of oxygen.

428. **Acetic acid:** its formula is  $\text{C}_2\text{H}_4\text{O}_2$ , or  $\text{C}_2\text{H}_3\text{O}-\text{O}-\text{H}$ . It is a monobasic acid, like nitric, hence its formula is conveniently written,  $\text{HC}_2\text{H}_3\text{O}_2$ , and the radical  $\text{C}_2\text{H}_3\text{O}_2$  occurs in all acetates, the H (one atom) being replaced by some positive element, as K, Na, Pb, etc. Acetic acid is the result of the fermentation of saccharine fluids, *after* alcoholic fermentation is over. It is prepared, however, from the residuary liquid obtained in the distillation of wood.

*Acidum Aceticum*, U. S. P.,  $\text{HC}_2\text{H}_3\text{O}_2 = 60$ , is a watery solution, composed of 36 per cent. of hydrogen acetate, and 64 of water. It is a clear, colorless liquid, of a distinctly vinegar-like odor, a purely acid taste, and a strongly acid reaction. Sp. gr. 1.048 at  $59^\circ\text{F}$ . Miscible in all proportions with water and alcohol, and wholly volatilized by heat. *Acidum Aceticum Dilutum* has 6 per cent. of absolute acetic acid, and a sp. gr. of 1.0083. *Acidum Aceticum Glaciale*, glacial acetic acid, is nearly or quite absolute acetic acid: at or below  $59^\circ\text{F}$ ., it is a

crystalline solid; at higher temperatures, a colorless liquid. It is very corrosive, and great care should be taken in removing the stopper from a full bottle. (O. & L.)

Acetic acid dissolves resins, camphor, fibrin, and coagulated albumin; it precipitates mucin. It blisters the skin and is a corrosive poison: antidotes are alkalies and alkaline carbonates, soap, etc. Glacial acetic acid is used by dentists, externally, as a caustic.

429. **Acetates:** important acetates are those of ammonium, aluminum, and lead.

**Spirit of Mindererus:** ammonium acetate,  $\text{NH}_4(\text{C}_2\text{H}_3\text{O}_2)$ . Saturate dilute acetic acid with ammonium carbonate and filter. Colorless, pungent, odorless liquid; should be freshly made.

Used in dentistry as a lotion, and internally as a refrigerant. Its formula is usually written  $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ . It is completely volatilized by heat.

430. **Aluminium acetate:** a solution of it, known as *Liquor Aluminii Acetatis*, occurs in pharmacy and is used by dentists as an antiseptic, disinfectant, and deodorizer. It contains from  $7\frac{1}{2}$  to 8 per cent. of basic aluminum acetate.  $(\text{Al}_2(\text{HO})_2(\text{C}_2\text{H}_3\text{O}_2)_4)$ , 324).

431. **Lead acetate** is known officially as *Plumbi Acetas*,  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O} = 378.5$ . For pharmaceutical purposes it is made from oxide of lead, acetic acid, and water:  $\text{PbO} + 2\text{HC}_2\text{H}_3\text{O}_2 + 2\text{H}_2\text{O} = \text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$ . Colorless, glistening, transparent crystals, efflorescent, soluble, sweetish astringent taste. Aqueous solutions become turbid from presence of carbon dioxide of the air, causing formation of carbonate of lead which is insoluble.

432. **Sub-acetate of lead:** the acetate and oxide, basic acetate,  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ ,  $\text{Pb}(\text{HIO})_2$ . Colorless liquid, more poisonous than the acetate. Precipitated by solutions of gum. Used in Goulard's extract, *liquor plumbi subacetatis*, a 25 per cent. solution of the sub-acetate.

433. **Lead water**, which is two fluidrachms of liquor plumbi subacetatis in a pint of distilled water, is used in dental practice as a local application. It is known as *Liquor Plumbi Subacetatis Dilutus*.

Compounds of lead are poisonous, but chronic poisoning is more common than acute; in the latter case, emetics should be administered or the stomach pump used, large draughts of milk containing white of egg given, and sulphate of magnesium dissolved in dilute sulphuric acid.



434. *Trichloroacetic acid* should really be considered under the head of chloral hydrate, for it is formed when the latter is oxidized by nitric acid. It is called also trichloroacetic acid. Its formula is  $C_1Cl_3O_2H$ , and is a colorless, crystalline solid, soluble in water and alcohol. It is a caustic, and coagulates albumin. It is used in dentistry as a germicide, and antiseptic. According to Dr. Filippowitch it is a powerful antiseptic even in 0.2 per cent. solutions, while in 1 per cent. or 2 per cent. solutions it destroys all forms of organic life; in 5 per cent. it does not arrest the growth of yeast, but does that of bacteria and micrococci.

435. **Benzoic acid:** formula  $C_7H_6O_2$ . This acid may be obtained from benzoin, naphthalin, toluol, or from the urine of herbivorous animals. It is a solid substance occurring in lustrous blades, or needles, but slightly soluble in cold water, soluble in boiling water, more soluble in alcohol and ether. Borax added to it increases its solubility in water. The acid is monobasic, like nitric acid. Most benzoates are soluble. Benzoic acid is an antiseptic, and is used in dentistry as such; also, as a local hæmostatic, in combination with powdered alum. It is one of the ingredients of Harris' Gum Wash.

*Ammonium benzoate*,  $NH_4C_7H_5O_2 = 139$ , is the benzoate most used. It occurs in the form of prismatic crystals, colorless, and transparent, or white and granular, soluble in 5 parts of water. It becomes yellow on long exposure to air. Benzoates, like benzoic acid, are antifermentative in action. Ammonium benzoate is administered in cases of phosphatic calculus, which, in time, it dissolves. *Lithium benzoate* has for its formula  $LiC_7H_5O_2 = 128$ .

436. **Eugenic acid.**—

Synonyms: eugenol, caryophyllic acid, oxidized essence of cloves.

Theoretical constitution:  $C_{10}H_{12}O_2$ .

Occurrence: found along with a hydrocarbon in oil of cloves.

Preparation: crude oil of cloves treated with potash is distilled, and the residue is subjected to the action of a mineral acid. The substance may also be obtained from cinnamon leaves.

Properties: colorless oil of sp. gr. 1.07, of spicy, burning taste, soluble in water, and in alcohol. Reddens litmus, and coagulates albumin. On contact with air, becomes darker and resinous.

Use in dentistry: as a germicide, obtunding agent, etc., etc.

427. **Hydrocyanic acid:** Acidum Hydrocyanicum, HCN or HCy, cyanhydric acid. Exists ready formed in juice of the bitter cassava; may be obtained from bitter almonds, kernels of plums and peaches, apple seeds, cherry laurel, etc.; clear, colorless, volatile liquid, peculiar pungent odor. The officinal acid contains about 2 per cent. of the anhydrous acid. Its compounds are cyanides, or *cyanurets*, as formerly termed.

438. Mercuric cyanide, HgCy or HgCN, has already been considered.

439. **Oleic acid:** formula  $C_{18}H_{34}O_2$ , or  $HC_{18}H_{33}O_2$ , or  $C_{17}H_{33}COOH$ , is of the fatty acid series, like acetic acid. It is found, in combination with glyceryl, in most animal fats and non-drying vegetable oils. Its salts are called *oleates*, and are definite chemical compounds.

Metallic oleates seem to exert an antiseptic action, not only on the fats with which they may be combined, but also on discharges from suppurating surfaces, etc., etc. The pure oleic acid is free from unpleasant odor or rancidity. Oleates of the alkaloids are prepared by dissolving the alkaloid in oleic acid. Important oleates are those of aluminum, arsenic, bismuth, cadmium, copper, iron, lead, mercury, silver, tin, zinc, and iron.

440. **Mercuric oleate** is of stable composition, as now prepared, and has all the therapeutic effects of mercury. It does not become rancid nor stain the linen. Its formula is  $Hg(C_{18}H_{33}O_2)_2 = 762$ . It is made from yellow mercuric oxide. The official U. S. P. oleate is a liquid.

#### PERCENTAGE OF METAL IN THE METALLIC OLEATES.

100 parts of oleate of	correspond to	Oxide	%
Aluminium . . . . .		$Al_2O_3$	5.86
Arsenic . . . . .		$As_2O_3$	21.55
Bismuth . . . . .		$Bi_2O_3$	22.22
Copper . . . . .		$CuO$	12.67
Iron (ferric) . . . . .		$Fe_2O_3$	8.89
Lead . . . . .		$PbO$	28.95
Mercury (precip.) . . . . .		$Hg$	28.32
Silver . . . . .		$Ag_2O$	29.77
Zinc . . . . .		$ZnO$	12.90

442. **Oxalic acid:**  $H_2(C_2O_4)$ ,  $2H_2O = 126$ .

Occurs in combination in *Oxalis* and in rhubarb. Made from sawdust by action of caustic alkali. Colorless, transparent crystals, readily soluble, odorless, intensely acid taste. Dangerous poison.

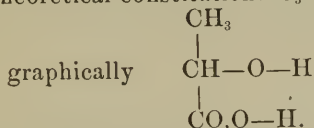
The treatment, in cases of poisoning, is to give lime or magnesia, chalk or magnesia, in very small quantities of milk, may be given, and subsequently emetics, if there is no vomiting.

443. The salts of oxalic acid are **oxalates**, and contain  $C_2O_4$ ; the acid is dibasic, hence calcium oxalate would have  $CaC_2O_4$  for its formula; potassium oxalate,  $K_2C_2O_4$ , etc., etc.

444. **Cerium oxalate** is  $Ce_2(C_2O_4)_3 \cdot 9H_2O_3 = 707$ .

445. **Lactic acid**: this acid is of importance to the dental student in view of the experiments of Miller, Black, Magitot, and others in regard to caries.

Theoretical constitution:  $C_3H_6O_3$ ,



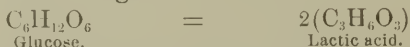
Composed of 3 atoms of carbon, 6 of hydrogen, and 3 of oxygen; by weight 36 parts of carbon, 6 of hydrogen, and 48 of oxygen. Molecular weight, 90. Formula, usually written  $HC_3H_5O_3$ , to denote the monobasic character of the acid.

Occurrence and preparation: lactic acid is the acid of sour cabbage and of sour milk. It is produced in these substances by the action of a special ferment called **lactic ferment**. It is found in several parts of the human body, namely, in the urine, intestinal juices, and in the gastric juice. It exists in many products after fermentation, as in beet juice, various vegetables, and nux vomica.

446. It, or isomeric modifications of it, occurs in the fluids which permeate muscular tissues. A variety called **sarco-lactic acid** is found in the muscles, and also in the hepatic cells. *Abnormally* lactic acid is found in the blood, particularly in leukaemia, pyaemia, etc.; it may be found in purulent discharges, in the saliva in diabetes, and in the urine, especially after phosphorus poisoning, in acute atrophy of the liver, leukaemia, trichinosis, and occasionally in rickets, and osteomalacia.

447. On a large scale lactic acid is prepared by the lactic fermentation, so called, of cane sugar and glucose. Flour is treated with dilute sulphuric acid, and its starch thus converted into glucose; the free sulphuric acid is neutralized with milk of lime, and sour milk is added, which gives rise to a fermentation in the sugars. This fermentation is checked before the so-called butyric fermentation sets in, by heating to the boil-

ing point. Calcium lactate is formed, and the hot solution, after filtration, is evaporated down, and allowed to crystallize. From calcium lactate, the lactic acid is obtained, by saturation with sulphuric acid. In the human body, lactic acid is possibly a derivative of sugar:



It is decomposed in the system into carbonic acid and water, perhaps splitting up first into butyric acid, carbonic acid, and hydrogen.

The lactic acid found in sour milk is produced by the transformation of the sugar of milk into lactic acid, by the influence of decomposing casein:



Properties: the officinal U. S. P. lactic acid is a colorless, syrupy, odorless, strongly acid liquid, containing 75 per cent. of lactic acid. Sp. gr., 1.212. It mixes readily with water, alcohol, and ether; is nearly insoluble in chloroform. Lactic acid possesses the property of dissolving calcium phosphate. It has been shown, by Magitot and others, to be capable of decomposing the teeth; sections of dentine, placed by Miller in infected culture fluids, were decomposed by the lactic acid formed. Leber and Rottenstein found that solutions of lactic acid, 1 part in 100 of water, decalcified the teeth.

Miller's experiments tend to show that, during caries, lactic acid is formed in the teeth, and in sufficient amount to destroy the dentine.

448. Lactic acid is a monobasic acid,  $\text{H}(\text{C}_3\text{H}_5\text{O}_3)$ ; its salts are *lactates*, and are all soluble. Phosphates dissolved in lactic acid form *lacto-phosphates*. Calcium lacto-phosphate is made by the action of lactic acid on calcium phosphate.

449. **Salicylic acid:** formula  $\text{C}_7\text{H}_6\text{O}_3$ , or  $\text{HC}_7\text{H}_5\text{O}_3$ , or  $\text{C}_6\text{H}_4(\text{OH})\text{CO}_2\text{H}$ . It is also called *oxybenzoic acid*. It forms a large percentage of oil of winter-green, but is prepared on a large scale by the action of carbon dioxide on sodium phenate (carbolate).

Properties: odorless, white and lustrous masses of fine, small colorless needles, soluble in boiling water and in alcohol; tasteless at first, but afterwards sweet and astringent, causing acidity of the fauces; soluble in cold water containing three parts of sodium phosphate. Antiseptic and disinfectant. Heated dry in a test tube, sublimes in beautiful needles before

melting-point is reached, and at higher temperature is dissipated. It is soluble in alcohol, ether, and glycerine. Its salts are salicylates; it is a monobasic acid  $\text{H}(\text{C}_7\text{H}_5\text{O}_3)$ , therefore, sodium salicylate, for example, is  $\text{NaC}_7\text{H}_5\text{O}_3$ . Salicylic acid is used in dentistry as an antiseptic, dissolved in water containing a little sodium phosphate or sodium sulphite, or in glycerine, or in ether. It, like many other acids, attacks the teeth slightly, hence is not suitable for mouth washes. It is acid in reaction.

450. **Tartaric acid:**  $\text{H}_2(\text{C}_4\text{H}_4\text{O}_6)$ , Acidum Tartaricum. Occurs in grapes, pineapples, tamarinds and other fruits as a tartrate. Prepared from crude tartar. Colorless, transparent crystals, soluble in water. Solutions are strongly acid, and deposit fungous growth.

In dentistry it is used, combined with "chloride of lime," to bleach discolored teeth.

451. **Cream of tartar** or **potassium bitartrate:** potassium acid tartrate,  $\text{KH}(\text{C}_4\text{H}_4\text{O}_6)$ , made from argols or crude tartar, a deposit on the sides of wine casks; odorless, gritty taste, white, almost insoluble in cold water, soluble in 15 to 20 parts boiling.

452. **Rochelle salt:** potassium sodium tartrate,  $\text{KNa}(\text{C}_4\text{H}_4\text{O}_6) \cdot 4\text{H}_2\text{O}$ . Large, transparent, colorless, slightly efflorescent crystals, mildly saline and bitter taste, readily soluble.

453. **Tartar emetic:** tartrate of **potassium** and a radical called **stibyl**, or potassium antimonyl tartrate,  $2\text{KSbOC}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O} = 664$ , is prepared by boiling 4 parts of antimonous oxide with 5 parts of cream of tartar, in 50 of water. It is soluble in 17 parts of water, but insoluble in alcohol. It is poisonous: treatment should consist in use of stomach pump or emetics, administration of tannin in form of tea, infusion of nut galls, oak bark, etc., and of stimulants.

454. **Other organic acids:** valeric or valerianic,  $\text{HC}_5\text{H}_9\text{O}_2$ ; citric,  $\text{H}_3\text{C}_6\text{H}_5\text{O}_7 \cdot \text{H}_2\text{O}$ .

## CHAPTER XIII.

### ALKALOIDS.

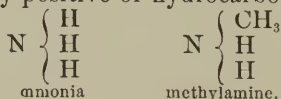
455. **Alkaloids** are artificial, natural or cadaveric. Artificial alkaloids are the various amines, as methyl-amine, ethyl-amine, etc. Methyl-amine is a gas, ethyl-amine a liquid, propyl-amine a volatile oil.

456. **The natural alkaloids:** a class of substances chiefly of vegetable origin, often active principles of plants, supposed to be like *alkalies*, hence name. Those containing no oxygen are volatile; those having oxygen are non-volatile. As a rule, are soluble in alcohol, ether, chloroform; contain nitrogen, turn plane of polarized ray of light to left (with few exceptions), furnish, with platinic chloride, double chlorides; have bitter taste, resemble alkalies in uniting with acids to form salts, of which the sulphates, nitrates, chlorides, and acetates are usually soluble, and the oxalates, tartrates, and tannates usually insoluble; in solution are precipitated by many re-agents, including iodine dissolved in iodide of potassium; very poisonous.

The alkaloids used in dentistry are for the most part *natural* alkaloids, as morphine, cocaine, etc., etc.

Cadaveric alkaloids, or *ptomaines*, are those found in putrefying animals or vegetable matter and, in certain pathological conditions, in the human body during life. Pyæmic fluid yields an alkaloid, which has been named *septicine*.

Most of the natural organic bases or alkaloids resemble the -amines or compound ammonias; an -**amine** may be regarded as formed by replacing one or more atoms in the ammonia ( $\text{NH}_3$ ) molecules by positive or hydrocarbon radicals, thus:





Some of the alkaloids are more like ammonium compounds than like amines. The molecular structure of the vegetable alkaloids is, in most cases, but very imperfectly understood.

457. **Aconitine:**  $C_{30}H_{47}NO_7$  is the alkaloid of aconite, *Aconitum Napellus*, occurring as a glacial mass or white powder, crystallizing with difficulty in rhombic plates. It is soluble in 150 parts of water, slightly soluble in ammonia water, soluble in benzol, soluble in 2 parts ether, soluble in  $2\frac{1}{2}$  parts chloroform. It has a sharp, pungent taste, and is one of the most powerful poisons known. It is fatal, probably, in doses of  $\frac{1}{13}$  grain. Samples of aconitine vary in strength, some being wholly inert, others powerfully poisonous. Morson's and Duquesnel's *crystallized* aconitine have about the same solubility, and are of about the same strength. Duquesnel's is in form of large crystals usually, some weighing  $\frac{1}{10}$  of a grain.

*Oleate of aconitine* contains usually 2 per cent. of the alkaloid.

Aconitine, in dental practice, is administered internally, for neuralgia of the fifth pair of nerves. The treatment, in cases of poisoning, should consist in administration of emetics, and of stimulants as ammonia and brandy, strong coffee, and tea. Liniments, and friction to the limbs and spine, should be used, mustard plasters applied to pit of stomach and slight galvanic shocks through the heart administered.

*Tincture* of aconite is a valuable local application in dentistry, especially when combined with various agents, as iodine, chloroform, etc. Poisoning by tincture of aconite is to be treated as above; the chief symptoms are numbness and tingling, great sense of fatigue, muscular weakness, etc., etc.

458. *Napelline*, an alkaloid obtained by Duquesnel from aconite, is less powerful than aconitine, and has hypnotic properties.

459. **Atropine:**  $C_{17}H_{23}NO_3$ . This alkaloid is from *Atropa Belladonna*. The *sulphate* of atropine is used in dentistry. Its formula is  $(C_{17}H_{23}NO_3)_2 \cdot H_2SO_4$ , and it is made by combining atropine with sulphuric acid and evaporating. [The hydrogen of acids is not replaced by alkaloids, when they combine with the acids; in this respect the compounds formed differ from compounds of the alkali metals and acids: thus, while atropine sulphate is  $(C_{17}H_{23}NO_3)_2$ ,  $H_2SO_4$ , potassium sulphate is  $K_2SO_4$ ].

Atropine sulphate is a white, crystalline powder, or forms small, colorless, silky prisms. It is soluble in 3 parts cold

water, and 10 parts 90 per cent. alcohol. The solution should be neutral to test paper. It is insoluble in ether, inodorous, of disagreeable, bitter taste, and is an active poison. In dental practice, it is used locally as an obtunding agent, etc., and also internally, for neuralgia, etc. The fatal dose is two grains; the treatment should consist in administration of emetics, and subcutaneous injection of pilocarpine or of morphine. Dryness of the throat, diplopia, vertigo, and in serious cases, delirium, are among the symptoms of poisoning by this substance.

460. **Chinoline** or **quinoline**:  $C_9H_7N$ .

This substance is an *artificial* alkaloid, and is not the active principle of any plant. It was first made from coal tar, then from cinchona, but now is made from nitrobenzole, aniline, and glycerine, to which sulphuric acid has been added, the mixture being heated and cooled alternately. It is a colorless, oily liquid, of sp. gr. 1.094, and boiling at  $460^{\circ}F$ . In chemical constitution it may be regarded as naphthalin,  $C_{10}H_8$ , in which *one* CH group is replaced by N.

Chinoline forms crystalline salts with acids. The one used in dentistry is the tartrate,  $(C_9H_7N)_2 H_2C_4H_4O_6$ , theoretically, but the real composition of German chinoline tartrate is said to be  $3C_9H_7N.4C_4H_6O_6$ , requiring 60.8 per cent. of tartaric acid. Chinoline tartrate forms (microscopic) columnar crystals; it is soluble in 75 parts of water at  $60.8^{\circ}F$ ., and in 150 parts of 90 % alcohol, and 350 of ether. Its taste is peculiar, somewhat burning, penetrating, and suggesting peppermint. It has a faint odor, slightly suggesting bitter almonds.

It is used in dentistry as an antiseptic, usually in 5 per cent. solution. It is sometimes combined with carbolic acid.

Quinoline enters into definite combinations with iodoform, forming a body having for its composition  $CH(C_9H_7NI)_3$ , called by Rhoussopolos methan-trichinoil-iodhydrate. One part of iodoform, dissolved in ether, is mixed with three of chinoline also dissolved in ether. Salts of chinoline should be kept away from the light.

461. **Cannabis Indica** products: the *tincture* of Cannabis Indica, diluted 3 to 5 times, has been used by A. Aaronson and others, as a local anæsthetic in extracting teeth.

462. **Cannabinum Tannicum** or cannabine tannate occurs as an amorphous, yellowish or brownish-gray powder, indifferent towards litmus, having a very faint odor of hemp, and a somewhat bitter, strongly astringent taste. When heated on platinum foil, it swells up and finally leaves minute traces of

a white ash. It is almost insoluble in cold water, alcohol, or ether, and dissolves but little on warming; but it is easily soluble in water or alcohol acidulated with hydrochloric acid.

463. **Cannabine:** Bombelon has suggested that pure cannabine be used, instead of the tannate, owing to the indefinite composition of the latter. He first prepares the tannate by precipitation, then decomposes this with oxide of zinc, and extracts the cannabine, which is obtained as a greenish-brown, air-dry, non-adhesive powder, volatile, without residue upon platinum foil.

Pure cannabine is tasteless, entirely insoluble in water, but easily soluble in alcohol, ether, and chloroform.

464. **Cannabinon:** this is the name of a new product recently prepared from *Cannabis Indica*. When cold, it has the consistence of a soft extract, when heated it appears as a viscid, brown balsam, transparent in thin layers, of a strongly aromatic odor and a sharp, bitter, and somewhat scratching taste. It is insoluble in water, easily soluble in alcohol, ether, petroleum ether, chloroform, benzol, bisulphide of carbon, ethereal and fixed oils. The solutions are golden-yellow when strongly diluted, brown when concentrated. When heated on platinum foil it leaves no residue. Its true chemical nature is not known.

465. **Cocaine:**  $C_{17}H_{21}NO_4$ . This now famous alkaloid is prepared from *Erythroxylon Coca*, a shrub indigenous to certain regions in South America. It is found chiefly in Peru and Chili, and the alkaloid is extracted from the leaves. The process of extracting cocaine from coca leaves is given in full in Squibb's Ephemeris, Vol. II., No. 7; it is too long for insertion here.

Pure cocaine crystallizes in colorless, four or six sided monoclinic prisms, soluble in 704 parts of water at  $53.6^{\circ}F.$ , easily soluble in alcohol, and still more so in ether. Cocaine melts near  $197^{\circ}F.$  Cocaine combines easily with dilute acids, forming easily crystallizable salts, which are more or less sparingly soluble in water, but soluble in alcohol. They are insoluble in ether, of bitter taste, and leave a transient sensation of insensibility upon the tongue.

The hydrochlorate, or muriate, of cocaine is the salt which has been most used. The *crystallized* hydrochlorate has for its formula,  $C_{17}H_{21}NO_4 \cdot HCl \cdot 2H_2O$ , when crystallized from aqueous solutions. Dried and rendered anhydrous, its formula is  $C_{17}H_{21}NO_4 \cdot HCl$ . Crystallized from alcohol (B.P.), its formula is the same as the latter, for it is anhydrous. Hydro-

chlorate of cocaine occurs in the form of short, transparent, prismatic crystals, permanent in air. It is sparingly soluble in water, but readily soluble in alcohol, ether, and in vaseline.

The hydrochlorate is termed *hydrochloride* by some authors; the hydrogen of the hydrochloric acid is not given off in the combination, as will be seen from the formula. 10 grains of the hydrochlorate in 1 fluidrachm of water make a four per cent. solution.

466. By far the most preferable compound of cocaine is the *hydrobromate*,  $C_{17}H_{21}NO_4 \cdot HBr$ .

467. *Cocaine citrate* is sometimes used: its formula would be  $(C_{17}H_{21}NO_4)_3 \cdot H_3C_6H_5O_7$ .

468. *Cocaine oleate* contains 5 per cent. of the alkaloid. Its formula would be  $(C_{17}H_{21}NO_4) \cdot HC_{18}H_{33}O_2$ .

469. The *salicylate of cocaine* is sometimes used. Formula,  $C_{17}H_{21}NO_4 \cdot HC_7H_5O_3$ .

470. **Salts of cocaine** are used in dentistry for their local anæsthetic, and anodyne effects, especially in alveolar pyorrhœa, extirpation of pulps of teeth, and that of hypersensitive dentine. They have also been used by injection, for extraction of teeth. Combined with menthol, and dissolved in alcohol, chloroform, or ethyl bromide, they are used as a lotion in neuralgia and odontalgia; for the same purpose, dissolved in oil of cloves. Toxic symptoms have followed injection of 6 drops of a 20 per cent. solution into the gums; relieved by inhalation of amyl nitrite, 3 drops at a time, 3 inhalations.

471. **Morphine:** morphine, morphia,  $C_{17}H_{19}NO_3$ ,  $H_2O$  exists as meconate of morphine in opium, which is the concrete, milky juice exuding on incising the unripe capsules of *Papaver Somniferum*, or white poppy. On account of the comparative insolubility of morphine, its *salts* are preferred for use in dentistry. Of these the acetate, hydrochlorate, and sulphate are officinal. They are all freely soluble in water.

472. *Morphine acetate*,  $(C_{17}H_{19}NO_3) \cdot HC_2H_3O_2$ ,  $3H_2O$ , occurs in the form of a white or yellowish white, amorphous or crystalline powder of bitter taste. Soluble in both alcohol and water. It is known officially, as *Morphinæ Acetas*.

473. *Morphine hydrochlorate*,  $(C_{17}H_{19}NO_3) \cdot HCl \cdot 3H_2O$ , also known as the hydrochloride, or muriate, occurs in the form of snow white, feathery, flexible, acicular crystals, of bitter taste and silky lustre, wholly soluble in both alcohol and water. *Morphinæ Hydrochloras* or *Murias* is the officinal term.

474. *Morphine sulphate*,  $(C_{17}H_{19}NO_3)_2 \cdot H_2SO_4 \cdot 5H_2O$ , occurs in form of crystals like the hydrochlorate, neutral in reaction, odorless, with bitter taste, soluble in both water and alcohol.

475. In dentistry the salts of morphine, especially the acetate and the hydrochlorate are used in devitalizing mixtures, and as obtunding agents, also for temporary relief of odontalgia, usually in combination with carbolic acid, oil of cloves, etc., etc. The acetate is used in nerve paste, rather than the sulphate, which latter is thought more irritating. Morphine is also given internally, in facial neuralgia, etc. The average fatal dose of the salts of morphine is 2 grains. Treatment of poisoning by these agents should consist in the use, by all means, of the stomach pump, washing out the stomach either with an infusion of coffee or green tea, or else with water in which finely powdered charcoal is suspended, using a fresh amount for each injection. If the pump is not used, vomiting should be encouraged, zinc sulphate in 5 grain doses, with fifteen minute intervals, being given, or *apomorphine hydrochlorate* subcutaneously, in doses of from 1-15 to 1-5 of a grain. Subsequently, 15 drops of tincture of belladonna, or 1-35 grain of atropine sulphate, subcutaneously, should be given. In the early stages of poisoning, the above mentioned treatment is often all that is necessary. In later stages, artificial respiration, and use of the battery (Faradic current) are imperative. Ene-mata of strong coffee may be administered.

476. **Quinine:**  $C_{20}H_{24}N_2O_2 + 3H_2O$ . This alkaloid occurs in cinchona bark, together with a number of others of which cinchona, quinidine, and cinchonidine are the most important. Quinine (crystallized) is a white powder, of bitter taste and alkaline reaction. It is nearly insoluble in water. Quinine is seldom used. Salts of it are sulphates, hydrochloride, salicylate, tannate, hydrobromide, valerianate, citrate (of iron and quinine), hypophosphite. The sulphate, bisulphate, hydrobromide, hydrochloride, and valerianate, are officinal.

477. **Quinine sulphates:** there are three of these, of which the diquinic sulphate  $(C_{20}H_{24}N_2O_2)_2 \cdot H_2SO_4 \cdot 7H_2O$ , is the officinal sulphate. It occurs as long, brilliant needles, efflorescing to a white powder. It is but sparingly soluble in water, 1 in 780 parts; in alcohol, 1 in 65. It is readily soluble in dilute acids, but nearly insoluble in ether or chloroform.

The official *bisulphate* is obtained by dissolving the sulphate in dilute sulphuric acid. Its formula is  $C_{20}H_{24}N_2O_2 \cdot H_2SO_5 \cdot 7H_2O$ .

There is another sulphate, obtained by dissolving quinine

in excess of dilute sulphuric acid. Its formula is  $C_{20}H_{21}N_2O_2 \cdot 2H_2SO_4 \cdot 7H_2O$ . It is not official. There is also a hypophosphite.

478. The salts of quinine are used in dentistry, in the treatment of various facial and neuralgic affections, and as ingredients of dentifrices.

479. The alkaloids of *Nux Vomica*.—

*Strychnine*, *Strychninum*, *strychnia*,  $C_{21}H_{22}N_2O_2$ . Occurs in seed of *Strychnos Nux Vomica*, or poison-nut-tree; also in *Strychnos Ignatia*, or St. Ignatius bean, found as strychnate or acetate.

Brucine is the other alkaloid, and is more soluble than strychnine.

The bitter taste of strychnine is perceptible in a solution containing but 1 part in 1,000,000. Strychnine sulphate,  $(C_{21}H_{22}N_2O_2)_2 \cdot H_2SO_4 \cdot 7H_2O$ , is officinal, and is readily soluble in water. Salts of strychnine are very poisonous,  $\frac{1}{4}$  of a grain having caused death. The treatment, in cases of poisoning, should consist in inhalation of chloroform, use of emetics, and, if possible, the injection into the stomach and withdrawal therefrom of powdered charcoal. Chloral hydrate and paraldehyde are sometimes administered as antidotes, and chloroform given internally.

480. **Veratrine:**  $C_{37}H_{53}NO_{11}$ , is an alkaloid found in *Veratrum sabadilla* and in *Cevadilla*, the seeds of *Asagrea officinalis*; also in *Veratrum album* or white hellebore, and *Veratrum viride*, or American hellebore. It occurs as a white, or grayish-white amorphous powder, of acrid taste; it causes violent sneezing, if inhaled. The *oleate* of veratrine is officinal, and is made to contain 2 per cent. of the alkaloid, and also 10 per cent.

In dental practice, veratrine in form of ointment is used for neuralgia, etc.



## CHAPTER XIV.

### ALBUMINOUS SUBSTANCES.

481. **Proteids:** a certain amount of knowledge in regard to those substances is essential. *Proteid* is the general term given to *albuminous* compounds, which form the chief part of the solids of the organs, blood, muscle, and lymph of animals, and seeds of plants. They are not crystalline, but colloid, do not diffuse through animal membranes, and readily putrefy when exposed to the air. They are white, flaky or granular, amorphous, and difficult to obtain in the pure state. Some are soluble, others insoluble in water; they are soluble in mineral acids and caustic alkalies, but almost insoluble in alcohol and ether. They have the peculiar property, however, of becoming insoluble either spontaneously, or after action of heat, or under influence of weak acids. They all yield what seems to be the same substance, *syntonin*, and, under the influence of the gastric juice, they are capable of generating peptones, or bodies easily assimilated, and very nutritious. Proteids, when heated, do not volatilize, but, when burnt, they give off products having odor of burnt horn. No accurate formulæ have been found for proteids, but they are known to contain carbon, hydrogen, nitrogen, oxygen, sometimes sulphur, sometimes phosphorus, and iron; in their ash, calcium phosphate is found. Their percentage composition, according to Wurtz, is carbon 52.7 to 54.5, hydrogen 6.9 to 7.3, nitrogen 15.4 to 17, oxygen 20.9 to 23.5, sulphur 0.8 to 2.2.

Proteids heated with a solution of mercurous nitrate, containing nitrous acid, assume a fine red color. On exposure to the air, proteids putrefy readily, fine granulations being developed in their interior, which change into vibrios, oxygen at the same time being absorbed, while carbon dioxide (carbonic acid gas), nitrogen, ammonia, sulphuretted hydrogen, hydro-

gen, ammonium sulphide, are discharged, and fatty acids, as butyric, lactic acid, -amines, leucin, tyrosin, etc., formed.

482. Proteids are classified by Hoppe-Seyler as follows:

1. Native albumins: soluble in water and precipitated by boiling: albumin of serum (blood albumin), and albumin of white of egg. Blood albumin is coagulated by a temperature of from 122°F. to 163°, but not by ether. Egg albumin begins to coagulate at 129°, coagulation increasing at 145° and 165°; it is precipitated by ether. Blood albumin, in solution, may be precipitated by concentrated nitric acid, citric or acetic acid plus potassium ferrocyanide, picric acid, and by many other substances.

2. Globulins: insoluble in water, soluble in 1 per cent. sodium chloride solution, but precipitated by saturated solution of common salt (except vitellin) or by addition of large quantity of water. The globulins are vitellin, crystallin, fibrinogen, fibrino-plastin, myosin or muscle fibrin. Syntonin may be prepared from myosin by treating the latter with a very little HCl.

3. Fibrin: a white, elastic, more or less fibrillated solid, insoluble in water and dilute sodium chloride solutions, prepared by rapidly stirring freshly drawn blood with a bundle of twigs, and washing the coagulum with water. Neutral solutions of fibrinogen and fibrinoplastin, mixed, in presence of fibrin ferment form fibrin. Fibrin does not dissolve in 1 per cent. solution of HCl, but swells, becoming soluble on addition of pepsin. Fibrin coagulates spontaneously on exposure to air.

4. Albuminates or derived albumins, sometimes called modified albumins: these are (1) acid-albuminate, known also as syntonin, albumose, and parapeptone, and (2) alkali albuminate found in blood corpuscles, blood serum, etc., and closely resembling casein.

5. Peptones: albuminous bodies are converted by the action of the gastric, pancreatic, and, doubtless, intestinal juices, into more diffusible and soluble bodies called peptones.

6. Amyloid substance or lardacein.

7. Coagulated albumin, as produced by action of heat on solution of serum albumin.

8. Special albumins found in cysts, dropsical fluids, etc. (Metalbumin, paralbumin.)

9. Collagens: albuminous bodies which do not yield syntonin when treated with dilute acids. Hot aqueous solutions

become jelly-like on cooling. The collagens are ossein, gelatin, chondrin, mucin, and elastin. Ossein is the proteid basis of bones, and contains 49.9 per cent. of carbon, 7.3 of hydrogen, 17.2 of nitrogen, 24.9 of oxygen and 0.7 of sulphur. Chondrin is the proteid found in cartilages.

483. *Mucin* is found in several parts of the body, and is one of the excretion products of the protoplasm of epithelial cells lining mucous surfaces, and of the secreting mucous cells of the sublingual and submaxillary glands. Its average composition is 49.5 % carbon, 6.7 % hydrogen, 9.6 % nitrogen, and 34.2 % oxygen. Dry mucin yields about 2.44 % ash, and contains no sulphur. In chemical constitution it is a nitrogenous glucoside, and probably an albumin derivative. Mucin, when obtained in the free state, occurs in white or yellow, thready, tenacious masses. It swells in water and mixes with it, but does not dissolve. It is soluble in dilute HCl, in weak alkalis, but insoluble in alcohol, ether, chloroform, dilute acetic acid, very dilute mineral acids. Acetic acid makes it shrink; caustic potash makes it more thready at first, then dissolves it. Its solutions are precipitated by acetic acid, and according to Oliver by alcohol, dilute mineral acids, and all vegetable acids.

Elasticin (or elastin) is the proteid composing the fibres of yellow elastic tissue.

484. 10. Proteid derivatives, leucin,  $C_6H_{13}NO_2$ , or amidocaproic acid, is an important proteid derivative, and is a constant product of the decomposition of albumin and nitrogenous substances. It is formed in decomposing cheese. Tyrosin,  $C_9H_{11}NO_3$ , is also a proteid derivative. Both are occasionally found in the saliva. Both unite with both acids and bases.

485. 11. Nitrogenized products of tissue metabolism: uric acid, sarkin, xanthin, guanin, etc., etc. **Uric acid**  $C_5H_4N_4O_3$ , is found in calculi, blood, urine, etc., etc. It is very sparingly soluble in water. It forms urates, of which lithium urate is the most soluble. Compounds of lithium are, therefore, administered in cases of uric acid calculi.

## CHAPTER XV.

### FERMENTATION AND PUTREFACTION.

486. **Fermentation:** according to Gautier, fermentation takes place wherever an organic compound undergoes changes of composition under the influence of a nitrogenous, organic substance, called a *ferment*, which acts in small quantities and yields nothing to the fermented substance. In a word fermentation is the decomposition of carbo-hydrates into simpler compounds, by the agency of living microbes.

*Putrefaction* is the name given to decompositions-fermentations in animal or vegetable organisms *rich in proteids*; in putrefaction, offensive odors are given off. Neither fermentation nor putrefaction is simply oxidation, but the presence of oxygen appears to be necessary to set up the change. The presence of water is also necessary to fermentation processes.

487. **Ferments:** ferments are in general of two kinds (1) **soluble or unorganized** (enzymes), and (2) **organized**.

488. **Soluble or unorganized** ferments are proteid substances having the power, under favorable circumstances, of causing certain chemical changes in bodies with which they come in contact, while they themselves undergo no change. Of these soluble ferments several are of vegetable origin, of which diastase is the most important; those of animal origin are pepsin, ptyalin, trypsin, etc., etc. They are all soluble in water, very diffusible, and, although not precipitated by boiling, nevertheless lose their activity. They neither give to, nor take from the bodies with which they are brought into contact. Their activity is destroyed by borax, but not by hydrogen dioxide. They do not reproduce themselves during the period of their activity.

489. *Diastase* or maltin is the ferment formed in grains, at time of sprouting, from the gluten. It converts starch into dextrin and maltose. *Ptyalin*, the salivary ferment, has the

same action; they act slowly on unchanged starch, but rapidly on cooked starch. The starch is first liquefied, then converted into dextrin, then into maltose. The amount of starch that can be transformed is anywhere from 2,090 to 100,000 times the weight of the ferment.

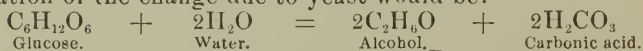
490. *Pepsin* is secreted in the glands of the stomach. It is obtained from the stomach of the pig, by digesting the mucous membrane in hydrochloric acid, and precipitation by sodium chloride. It is a yellowish or grayish-white powder, insoluble in water, but soluble in water to which glycerine has been added. It is of peculiar odor and bitter, nauseating, taste. Heat of 230°F. decomposes it and renders it inert, but its solutions lose activity at much lower temperatures. The temperature most favorable for its activity is 98.6°F., and presence of a dilute acid as hydrochloric, lactic, phosphoric, etc., is required to develop its peculiar action.  $\frac{1}{10}$  per cent. NaCl also favors its action, but half of one per cent. hinders it. Carbolic acid or excess of alcohol retards its action. **In dental practice, pepsin** is used in the treatment of putrid pulps, as an antiseptic and deodorizer.

491. In the *American Druggist* may be found the results of examination of 8 samples of pure concentrated pepsins in powder form, and 5 of pepsins in scale form. 1 grain of the powdered pepsins digested in 6 hours all the way from 420 to 914 grains of albumin; 1 grain of the scale pepsins from 340 to 730 grains.

492. **Organized Ferments:** soluble ferments, as we have seen, are responsible for all physiological fermentations; on the other hand, pathological fermentations are caused by *organized ferments*, which are forms of low organisms of vegetable origin, whose activity is greatest at temperatures ranging from 68°F. to about 104°. Their activity is retarded by temperatures below or above these limits, and temperatures near 212°F. entirely destroy their activity, as does also hydrogen dioxide. The latter agent stops also the chemical change which is the direct result of the growth of the organized ferments. These ferments are remarkable in that a very minute quantity will grow, and exert its action, as long as appropriate nourishment is furnished it. Organized ferments have, then, powers of growth and reproduction, and the ferment power cannot be separated from the ferment organism by filtration or by any solvent. The chief food of organized ferments is ammoniacal salts, and alkaline phosphates. The most important of the organized

ferments are yeast (alcoholic ferment), acetic acid ferment, lactic and butyric acid ferment, the ferment of "thrush," and the putrefactive ferments.

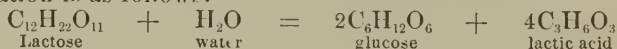
493. *Yeast spores* are always to be found either in the air, or on fruit. Their chief action is to convert saccharose into grape sugar, and then to change the latter into alcohol, and carbonic acid, with a trace of succinic acid and glycerine. The equation of the change due to yeast would be:



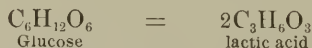
Yeast is known as *Torula (Saccharomyces) cerevisiae*.

494. The *acetic acid ferment* belongs to the bacteria family, and grows in alcoholic solutions containing a little albuminous matter or various salts, as those of ammonium, or alkaline and earthy phosphates. It acts by changing alcohol to acetic acid, by oxidation, the *mycoderma aceti* acting as an oxygen-carrier.

495. The *lactic acid ferment* grows in a neutral or alkaline medium, and best without oxygen, at a temperature of from 95° to 104°F. Various kinds of sugar and dextrine, under the action of *bacterium lactis*, are converted into lactic acid, in the presence of a decomposing albuminous substance, especially casein, and water. The process is also favored by presence of chalk, or alkaline carbonates, which neutralize the lactic acid as fast as it is formed; were it not for this, the production of acid would prevent the continuance of the fermentation. The equation is as follows:

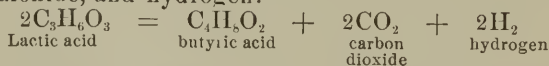


also,



Lactic acid is, according to Miller, formed in the teeth during caries.

496. The *butyric ferment* goes hand in hand with the lactic. Lactic acid is split up by its agency into butyric acid, carbon dioxide, and hydrogen:



497. The *thrush ferment* is a fungus, which appears on the mucous membrane of the mouths of infants, especially of those brought up by hand. The saliva becomes acid, and white spots appear, especially on the tongue, gums, and soft palate.



498. Various forms of bacteria cause *putrefactive fermentation* in proteids, by which the latter are decomposed into fats, tyrosin, leucin, ammonia, sulphuretted hydrogen, carbon dioxide, hydrogen and nitrogen. It is from the decomposition of proteids that the sulphuretted hydrogen in the mouth is formed.

499. **Classification of bacteria, etc.:** the term *microbe* is used, in general, to designate the minute organized beings which are found on the borderland between animals and plants; in the majority of cases they may be regarded as true plants. Broadly, microbes may be divided into *parasitic fungi*, and *moulds, ferments, and bacteria*, and to the last the term *microbe* in particular is usually applied.

500. **Fungi** are plants devoid of stems, leaves and roots; they consist only of cells in juxtaposition, devoid of chlorophyll; they never bear a true flower, and are simply reproduced by means of very minute bodies, usually formed of a single cell, called a *spore*, and which represents the seed. Among the parasitic fungi and moulds may be found the rust of wheat and grasses, the ergot of rye, mould of leather and dried fruit, potato fungus, mildew, the fungi of certain skin diseases as tinea, thrush, etc.

501. **Ferments** are closely allied to a variety of fungus called *microsporon*, but as they live in liquids or on damp substances they are classified by many among the Algæ, a species of water-fungi. Ferments, however, differ from Algæ in not containing chlorophyll. Each plant of the ferment variety is usually composed of a single cell, spherical, elliptical, or cylindrical, formed of a thin cell-wall, containing a granular substance called protoplasm, which is the essential part of the plant. The cells have an average diameter of ten micro-millimetres; they grow, and bud, and each divides into two parts. Among the ferments, we find those of wine, beer-yeast, bread-yeast, etc., etc.

502. **Bacteria** are alike in form and organization to ferments, but, as a rule are of smaller size. Microbes or bacteria (Schizophyta or Schizomycetes) appear, under the microscope, as small cells of a spherical, oval or cylindrical shape sometimes detached, sometimes united in pairs, or in articulated chains and chaplets. The diameter of the largest of these cells is but two micro-millimetres, and that of the smallest is a fourth of that size. A power of from 500 to 1,000 diameters is necessary to make them clearly visible under the microscope.

Morphologically, Dujardin-Beaumetz recognizes six forms: (1) Monad, micrococcus, or moner, immobile point-like microbes, often regarded as spores. (2) Bacteridia and bacillus, immobile linear microbes. (3) Bacteriens, cylindrical mobile microbes, the end rounded, or the body indented in the centre, so as to form a figure of 8. (4) Vibriones, eel-shaped, undulating, mobile, and flexuous microbes. (5) Spirilla and spirochetæ, corkscrew-like, spirally moving microbes. (6) Capitated microbes, *bacterium capitatum*, being mobile rods, with one or both extremities long, globular, and more refractive than the rest of the body.

This classification has reference to the cells as seen singly or in very limited numbers; when aggregated so as to form colonies there are distinguished four forms:

1. Torula, in the form of a necklace, composed of micrococci.
2. Leptothrix, made up of bacteria, clustered end to end.
3. Mycoderma, immobile, composed of bacteria in sheets.
4. Zooglæa, being masses of bacteria, immobile, inclosed in a sort of jelly which holds them together.

503. Varied conditions of existence influence the form taken by these organisms, so that distinctions into genera and species are not as yet made on precise data. The *microbe of acetic fermentation* is a true bacterium (bacterien). The *microbe of lactic fermentation* is also a bacterium. The *microbe of butyric fermentation* is a bacillus.

504. In **putrefaction** or fermentation of dead organic matter exposed to the air, the substances are first rapidly covered with moulds; they lose coherence, and after a few days give off carbonic acid, nitrogen, hydrogen and fetid effluvia, due largely to carburetted, sulphuretted, and phosphoretted hydrogen, and to the circulation of decomposing organic particles. The microbes which appear simultaneously with the moulds, penetrate deeply into the tissues, disintegrate them by feeding at their expense, and the putrid condition increases; then the decomposition changes its nature and becomes less intense. The putrefied matter is finally dessicated, and leaves a brown mass—a complex mixture of substances combined with water, and of fatty and mineral substances, which gradually disappear by slow oxidation. (Gautier.) In such putrefaction of animal matter in water are found microbes in the form of globules or short rods (*Micrococcus*, *Bacterium termo*, *Bacillus*, etc.), either free, or in a semi-mucilaginous mass, to which the term *Zoogloea* has been given. These

microbes deprive the liquid of all its oxygen. A thin layer on the surface absorbs oxygen; in the interior, albuminoid matter is changed into more simple substances, and the microbes on the surface change the latter into gases. A substance remains rich in fats, earthy and ammoniacal salts, fit to serve as nutriment to plants.

505. **The microbes of the mouth** of a healthy man are numerous, and include (1) *Spirochæte*, (2) a species of *Sarcina*, and (3) more especially, a large organism called *Leptothrix buccalis* which is never absent from the rough surface of the tongue nor the interstices of the teeth. The saliva contains a *micrococcus* which may become exceptionally virulent.

**The microbe of dental caries:** according to Miller, dental caries is chiefly due to the development of one or more species of bacteria. The microbe most common in decayed teeth is very polymorphic, *micrococcus bacterium*, chains, and filaments are found which are but different phases of the same plant, which is also responsible for acid fermentation in the mouth, and for the formation of lactic acid.

506. **The microbe of pus**, as found in blood poisoning, is termed *Micrococcus septicus*; it may either appear free or in the form of chaplets (*vibrio*), or in the interior of the colorless corpuscles of pus, or embryonic cells, which, in form of *zooglaea*, it ruptures. The germs of *Micrococcus septicus* are introduced into the blood, and multiply there, through the exposed surface from a wound or by agency sometimes of the instrument causing the wound. When bacteria multiply in the blood, they must necessarily have an irritating effect on the walls of the capillaries, and the cells are transformed in consequence into embryonic or migratory cells which differ but slightly from the colorless blood-corpuscles and are pus-corpuscles. (Trouessart).

507. **Action of pathogenic microbes:** this is complex and is analyzed according to Trouessart as follows: (1) the action of a living parasite nourished by and multiplying at the expense of the fluids and gases of the system; (2) the formation by this parasite of a poisonous substance (ptomaine), the elements of which are derived from the organism, and it, the ptomaine, acts as a poison on this organism.

508. **Pus and suppuration:** according to Knapp, suppuration in every case depends on the action of microbes. Pus being defined as an albuminous, non-coagulable fluid containing multitudes of leucocytes, suppuration is deemed to be the split-

ting up of living nitrogenous tissue into simpler compounds through influence of certain bacteria.

Note: this theory has not been accepted by all observers.

509. **Protection against microbes:** this is to be accomplished by what is, in general, called *disinfection*. Substances used for the purpose of preventing zymotic diseases so-called have been classified as follows:

1. *Diluents:* air and water.
2. *Absorbents:* dry earth and plaster of Paris.
3. *Destructive agents:* lime and sulphate of iron are most important. Under certain circumstances, permanganate of potassium, caustic potash, mineral acids.
4. *Antiseptics:* these check the development of the organism of putrefaction but do not necessarily kill disease germs. Most important: alcohol, sulphate of iron, borax. Commonly used: salt, saltpetre, carbolic acid.
5. *Germicides:* agents which have the power of killing disease germs: most important are chlorine and substances which contain it, as corrosive sublimate. All germicides are antiseptics, but the antiseptics proper are not germicides. Nearly all bacteria are destroyed in a very short time by high temperatures.

Koch and Wolffhugel, as the outcome of a number of most carefully conducted experiments, report the following conclusions:

1. Bacilli without spores are incapable of withstanding the influence of an atmosphere heated to 100°C. for one hour and a half.
2. Spores of the fungi require for their destruction a temperature of 110°–115°C. (220°–230°F.) continued for one hour and a half.
3. Spores of bacilli are only destroyed by remaining for three hours in an atmosphere heated to 140°C. (284°F.)
4. In a heated atmosphere the heat enters the objects to be disinfected so slowly that after exposure to 140°C. (284°F.). for from three to four hours, objects of moderate dimensions, such as a bundle of clothes or a pillow are not yet disinfected.
5. The application of such a heat, 140°C. (284°F.), for three hours or more, as is necessary for complete disinfection, is more or less injurious to most textile fabrics.

In another essay of the same collection it is stated that in all cases where heat is at all applicable as a means of disinfection, the method of employing steam and closed apparatus is

much to be preferred to any other method. Generally, as stated by Dujardin-Beaumetz, the bacteria are destroyed by a temperature of from 144°–160°F.

510. **Application of the germ theory to dentistry:** experiments were made by Miller with various antiseptics, to ascertain which would answer best to retard or to prevent fermentation in the mouth. The following are the results:

The fermentative action is

	Prevented by 1 in	Arrested by 1 in
Corrosive Sublimate.....	500,000	100,000
Nitrate Silver.....	100,000	50,000
Iodine (in Alcohol).....	15,000	6,000
Iodoform.....	10,000	5,000
Naphthalin.....	9,000	4,000
Ess. Oil Mustard.....	5,000	2,000
Permang. Potassium.....	2,000	1,000
Oil Eucalyptus.....		600
Carbolic Acid.....	1,000	500
Hydrochloric Acid.....	1,000	500
Carbonate Sodium.....	200	100
Salicylic Acid.....	125	75
Alcohol, absol.....	25	10

These results are of considerable interest not only to dentists, but also for the preparation of efficient tooth-powders.—*Am. Druggist.*

Miller claims to sterilize the mouth, cavities in carious teeth, etc., by the following mixture:

Thymol.....	4 gr.
Benzoic Acid.....	45 gr.
Tincture of Eucalyptus .....	3½ fl. dr.
Water.....	25 fl. oz.

The mouth is to be well rinsed with this mixture, especially just before going to bed, since most of the damage by fermentative and putrefactive processes in the mouth is done at night, during sleep.

511. As an antiseptic in tooth-powder, Macgregor suggests *boracic acid*; he has used for years a powder containing amongst other ingredients 40 grains of boracic acid to 440 of other substances.

A mouth wash containing 1 part of corrosive sublimate in 5000 can be made as follows: one grain of the perchloride of mercury and 1 grain of chloride of ammonium to be dissolved in 1 ounce of eau de cologne, and a teaspoonful of the solution to be mixed with two-thirds of a wineglassful of water.

An antiseptic mouth-wash, containing chinoline tartrate, may be made as follows:

Chinoline tartrate.....	3 parts
Oil of peppermint... ..	2 "
Alcohol.....	40 "
Distilled water.....	280 "

512. In washing plates of artificial teeth, regard must be had for their metallic character; for example, a plate containing aluminum is said to be affected by a corrosive sublimate solution more readily than by carbolic acid.

513. The various agents, germicides, antiseptics, etc., are of importance to the dentists not only from a hygienic point of view, but also in the treatment of various diseases, as, for instance, alveolar pyorrhœa. Hydrogen peroxide, and also zinc iodide, in solution are recommended by Harlan for this disease.

Iodoform and eucalyptus, iodoform and oil of cinnamon, solutions of aluminum chloride, carbolic acid (with equal parts caustic potash—Robinson's remedy), salicylic acid, carvacrol, thymol (in glycerine), chinoline tartrate, creasote, eugenol, resorcin, Sanitas oil, Listerine, boro-glyceride, are antiseptics most commonly used by dentists in the treatment of various diseased conditions.

For an antiseptic, P. Miquel prefers hydrogen peroxide. Abbott recommends half a grain of corrosive sublimate in twenty-one fluid ounces of water. *Deodorizers*: for fetor of the breath, etc., chlorinated lime solution, chlorine water, chlorinated soda, permanganate of potassium solution, phenol sodique, are used; also certain vegetable substances, as orris root.



## CHAPTER XVI.

### THE TEETH.

514. **Structure:** the chief mass of a tooth consists of a substance called *dentine*, in the interior of which is the *pulp cavity*. The crown of the tooth is invested by a substance called *enamel*, which extends some distance down the neck, but the fangs are covered by a substance known as *cement* (*crusta petrosa*). Before describing the dental tissues further, we shall pay attention for a moment to the chemistry of *bone*.

515. **Bone** consists of an organic substance called *ossein*, which as we have seen is a proteid substance, belonging to the collagens, intimately combined with a mineral substance called *bone earth*, in proportion of about 30 of ossein to 70 of bone earth. The latter is a mixture of various salts, as calcium phosphate, calcium carbonate, calcium fluoride, and magnesium phosphate, of which the most abundant in quantity are the calcium phosphate and carbonate. Bone contains also water and fat. The ossein of bone resembles gelatin, and by boiling ossein with water it is changed into gelatin.

Hoppe Seyler gives the general composition of normal, undried bone as:

Water.....	50.00 per cent.
Fat.....	15.75 " "
Ossein.....	11.40 " "
Bone earth.....	21.85 " "

Most of the water is combined in the ossein. Expressing the composition of bone in order to show the relative percentage of organic and inorganic substances we find it, according to Heintz, as follows:

Inorganic substances.....	69.53 to 68.88
Organic substances.....	30.47 " 31.12

Analysis of the *ash* shows that of the inorganic substances,

tribasic calcium phosphate,  $\text{Ca}_3(\text{PO}_4)_2$ , constitutes from 83.89 to 87.7 per cent., calcium carbonate 8.9 to 13.03, tribasic magnesium phosphate, 1.04 to 1.7 per cent., calcic fluoride and chloride, 0.76 to 4.9 per cent. Berzelius' analysis of bone resulted as follows:

Ossein.....	32.17
Calcium phosphate....	51.04
"    fluoride .....	2.00
"    carbonate .....	11.30
Soda with sodic chloride.....	1.20
Magnesium phosphate.....	1.16
Vessels.....	1.13

516. The inorganic constituents of bone increase slightly with age, and the bone becomes more porous. The *marrow* of bones is of different composition, according to locality, but in the long bones (yellow marrow) is 96 per cent. fat with some cholesterin, hypoxanthin, albumin and, occasionally, lactic acid. *Red* marrow contains a small proportion of fat, much albumin and salts, and an acid resembling lactic acid. In diseases of bone the inorganic salts change in quantity and the organic constituents in quality.

#### [ANALYSIS OF BONE IN CARIES OF VERTEBRA.

Calcium phosphate.....	33.91
"    carbonate.....	7.60
Magnesium phosphate.....	1.93
Soluble salts, chiefly NaCl.....	0.61
Ossein, etc.....	19.58
Fat.....	1.22 (Valentin).

#### ANALYSIS OF BONE IN NECROSIS.

Calcium phosphate, etc.....	72.63
Calcium carbonate....	4.03
Magnesium phosphate.....	1.93
Soluble salts.....	0.61
Ossein.....	19.58
Fat.....	1.22

517. Turning now to the chemical constitution of the **teeth**, we find that the *cement* has the structure of bone, and its chemical composition is almost the same, namely organic substances 30 parts, inorganic 70 parts; of the latter nearly 65 parts of the 70 are composed of *phosphates* of calcium and magnesium, and *carbonate* of calcium as follows:

Calcium phosphate.....	60.7
Magnesium phosphate.....	1.2
Calcium carbonate.....	2.9 (Bibra).

518. The *enamel* of teeth is nearly all inorganic matter; in the enamel of some animals, as the dog, there seems to be no organic matter at all. On an average in man the inorganic constituents are from 95 to 97 per cent. in amount, the organic from 5 to 3; in the teeth of young infants, however, the inorganic matter is only from 77 to 84 per cent.

## AVERAGE COMPOSITION OF THE ENAMEL.

Water and organic substances.....	3.6	
Calcium phosphate and fluoride.....	86.9	
Magnesium phosphate.....	1.5	
Calcium carbonate .....	8.0	(Charles).

## HOPPE-SEYLER'S ANALYSIS.

Calcium carbonate and phosphate, $\text{Ca}_{10}\text{CO}_36\text{PO}_4$ ....	96.0
$\text{MgHPO}_4$ (neutral phosphate of magnesium).....	1.05
Organic substances.....	3.60

519. The *dentine* is more like bone than the enamel is, but less like it than the cement. It is composed of animal matter impregnated with earthy salts. It averages from 26 to 28 per cent. organic substances to 74 to 72 of inorganic matter.

## ANALYSIS OF DENTINE.

	Woman.	Man.
Organic matter—ossein and vessels.....	27.61	20.42
Calcium phosphate . . . . .	66.72	67.54
Calcium carbonate .....	3.36	7.97
Magnesium phosphate.....	1.08	2.49
Other salts (NaCl, etc.) .....	0.83	1.00
Fat.....	0.40	0.58

## ANALYSIS OF HOPPE-SEYLER.

$\text{Ca}_{10}\text{CO}_36\text{PO}_4$ .....	72.06
$\text{MgHPO}_4$ .....	0.75
Organic substances.....	27.70

The organic matter of the dentine resembles the ossein of bone, but according to Hoppe-Seyler, the walls of the canaliculi are invested with a body resembling *keratin* or *elastacin*. [Keratin is a proteid substance and is the chief component of epidermic structures. It is noticeable for the large amount of sulphur it contains. It is closely related to albumin, yielding leucin and tyrosin when decomposed. Its percentage composition is C = 50—51.6, H = 6.4—7.2, N = 16.2—17.9, S = 0.7—5.0, O = 20—22.4. It is insoluble in alcohol and ether, swells up in boiling water, and is soluble in the caustic

alkalies. It is not liable to decomposition, and melts when heated.

*Elasticin* is related to keratin, and is the substance composing the fibres of yellow elastic tissue. It is sometimes called *elastin*. It yields leucin but not tyrosin. Its percentage composition is C = 54.32, H = 6.99, N = 16.75, ash = 0.5].

Dentine contains 4 per cent. less water than bone. Its specific gravity according to C. Krause is 2.080. The walls of the canaliculi do not yield gelatin, but the ground substance of dentine may be transformed into gelatine, when heated in a Papin's digester. The dentine globules are not convertible into gelatin, and resist the action of acids better than other portions of the tissue do.

Of the three substances of which the teeth are composed we find that the enamel is the hardest, the dentine next, and the cement the least. The enamel is hard and brittle.

If the enamel be treated with dilute hydrochloric acid, the calcium phosphate is dissolved, and there remain prismatic fibres which resemble epithelium, and are not attacked by boiling water. If the cement be treated with an acid its inorganic constituents are dissolved, and there remains an organic residue which is said by Hoppe-Seyler not to yield gelatin; [according to some authors this substance *does* yield gelatin]. If the dentine be treated with acids, organic matter is left, most of which yields gelatin, but some does not. According to Bibra, molar teeth appear to contain more mineral matter than incisors.

520. Various analyses (tabulated for reference):

	CEMENT OF TOOTH.	
	Of ox (Fremy).	Of man (Bibra).
Ash (containing an average of) 67.1 per cent. ....	70	58 per cent.
Calcic phosphate.....	60.7	"
Magnesian " .....	1.2	"
Carbonate of lime.....	2.9	"

#### DENTINE OF TOOTH, (HOPPE-SEYLER).

$\text{Ca}_{10}\text{CO}_3^6(\text{PO}_4)$ .....	72.06
$\text{MgHPO}_4$ .....	0.75
Organic substances.....	27.70

#### DENTINE (BIBRA).

	Adult woman.	Adult man.
Organic matter—ossein and vessels..	27.61	20.42
Phosphate of lime.....	66.72	67.54
Carbonate " .....	3.36	7.97
Phosphate of magnesia.....	1.08	2.49
Other salts (NaCl, etc.).....	0.83	1.00
Fat.....	0.40	0.58

## ENAMEL OF TOOTH.

Water and organic substances.....	3.6
Calcic phosphate and fluoride.....	86.9
Magnesian phosphate.....	1.5
Calcic carbonate.....	8.0

It is thus given by Hoppe-Seyler:

$\text{Ca}_{10}\text{CO}_36(\text{PO}_4)$ .....	96.00
$\text{MgHPO}_4$ .....	1.05
Organic substances.....	3.60

## ENAMEL AND DENTINE COMPARED—OX (AEBY).

	Enamel.	Dentine.
Organic substance and water.....	3.60	27.70
Inorganic “.....	96.40	72.30
In 100 parts ash--		
Calcic phosphate.....	93.35	91.32
“ carbonate.....	4.80	1.61
“ oxide.....	0.86	5.27
Magnesian carbonate.....	0.78	0.75
Calcic sulphate.....	0.12	0.09
Oxide of iron.....	0.09	0.10

## DENTINE, CEMENT, AND ENAMEL COMPARED.

	Ash.	Calcium Phosphate.	Magnesium Phosphate.	Calcium Carbonate.
Dentine.....	76.8	70.3	4.3	2.2
Cement.....	67.1	60.7	1.2	2.9
Enamel.....	96.9	90.5	traces	2.2

Minute amounts of chlorine and fluorine exist especially in the enamel. (Fremy).

## CEMENT AND DENTINE COMPARED, (AEBY).

	Cements.	Dentine.
Calcium phosphate.....	61.32	63.35
“ oxide.....	5.27	0.86
“ carbonate.....	1.61	4.80
“ sulphate.....	0.09	0.12
Magnesium carbonate.....	0.75	0.78
Ferric oxide.....	0.10	0.09
Organic substances.....	27.70	26.00

## ANALYSIS OF TEETH BY BERZELIUS.

Organic matter.....	28.0
Calcium phosphate.....	64.4
Magnesium phosphate.....	1.0
Calcium carbonate.....	5.3
Sodium “ and chloride.....	1.3
Water, animal matter, alkali (traces)....	0.0

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100.0

521. **Action of Various Substances on the Teeth.**—

Owing to the solubility in acids of the phosphates and carbonates of magnesium and calcium, it stands to reason that a great part of tooth structure may be destroyed when brought into contact with substances either themselves acid or of strong acid reaction. According to many authorities as Westcott, Allport, Mantegazza, Magitot, Leber and Rottenstein, etc., the strong mineral and vegetable acids act promptly upon the teeth. Leber and Rottenstein found that in time a solution of *tartaric acid*, 1 in 1000, attacked the enamel, as did also *crushed grapes*, or a 1 in 1000 solution of *acetic acid*, of oxalic acid, or 1 in 100 solution of *alum*, or 1 in 1000 of *lactic acid*. According then to Leber and Rottenstein, as also Westcott, Allport, and Mantegazza, all the vegetable acids without distinction attack the enamel of the teeth. It is well to bear in mind such substances in daily use as are either acids or have an acid reaction, and hence should not be allowed to come constantly into contact with the teeth; these are the *mineral acids*, as sulphuric, nitric, hydrochloric, phosphoric, etc., the *vegetable acids*, as oxalic, acetic, tartaric, lactic, benzoic, salicylic, tannic, etc., *many compounds of the metals*, as ferric chloride ("tincture of iron"), acid phosphates of calcium, magnesium, etc., etc., alum, arsenic, corrosive sublimate, zinc chloride, cream of tartar (acid potassium tartrate), the sulphate and subsulphate of iron, chromic anhydride (chromic "acid" so-called). Solutions of hydrogen dioxide are acid in reaction; some preparations of it contain much less acid than others.

C. A. Brackett has examined a number of substances used in dentistry, and finds the following to be acid in reaction: Prof. Wetherbee's Dental Obtundent.

Ordinary alcoholic tincture of myrrh (the specimen was some months old).

A solution of 1 part chloride of zinc to 2 parts glycerine.

Glycerine, 2 parts, tincture of aconite root, 1 part.

He found also, as might be expected, that the liquid portion of various "cements" was acid in reaction.

Among substances *but feebly acid* in reaction may be mentioned boracic acid.

Among substances which *if pure* should be neutral in reaction we find silver nitrate, carbolic acid. Among articles of diet which tend to attack the teeth may be mentioned acidulated drinks, foods readily becoming acid, and saccharine articles shown by Miller to be converted into lactic acid.



522. **Chemistry of caries:** three theories have been advanced to account for caries, namely, *the chemical theory*, *the vital theory*, and *the germ theory*. According to the **chemical theory**, the substance of the tooth is decomposed by an acid; this acid acts more readily on dentine than on enamel, hence the tendency to the enlargement of the cavity toward the internal portions of the tooth. The origin of the acids thus supposed to produce caries has been a subject of much inquiry. For a time the saliva was supposed to furnish them, but it was shown that decay occurred in mouths, in which the saliva was habitually normal, and did not occur in some mouths in which the saliva was habitually acid. (Black). The hypothesis that the acid is furnished on the spot, through the decomposition of the food, seems much more feasible, and the production of the acid, if coming through fermentation, decomposition, or remoleculization of the substances lodged about the teeth makes it easy for one to "glide from the old acid theory to the new germ theory." (Black).

The **germ theory** of caries sets forth, according to Miller, that no less than five different fungi exist in carious human teeth. These fungi have the power of causing fermentation in solutions containing fermentable carbohydrates and producing, as one of the products, optically inactive *lactic acid*. Free oxygen is not required for the production of this fermentative action, though it is probably accessory to the life and growth of the fungi. They have the power of inverting sugar, that is, to convert infermentable cane-sugar into fermentable glucose. When sound teeth are exposed to the action of these fungi, they are rapidly deprived of lime, and, on microscopic examination, large masses of bacteria will be found in the dental channels. The equation for the production of lactic acid has already been given.

The **vital theory** supposed caries to result from an inflammation of the structure of the dentine, terminating in the final breaking down of the part; and as the structure is incapable, as is well known, of physiological repair, a cavity is the inevitable result. According to Black, it is still very uncertain whether any of the theories in regard to caries are correct, but more than one explain the phenomena with sufficient accuracy to be of great value, both in the prevention and treatment. Whatever may be the theories, it is claimed that the teeth deteriorate as an effect of mental overwork; among the hard-worked pupils of the Paris public schools, the teeth be-

come deteriorated in a few weeks after entry. According to Parker, increased decay and increased sensibility of the dentine are apparent in men training for athletic trials. Williams has shown that any mental strain shows itself in the teeth in a short time.

## CHAPTER XVII.

### THE SALIVA.

523. **The Saliva:** the saliva is the product of the combined secretion of the parotid, submaxillary, and sublingual glands. In the mouth these secretions are mixed together, and, also with it, the mucus secreted in the oral cavity.

Physical characteristics of mixed saliva: *taste*, none; *color*, none; *odor*, none; *specific gravity*, 1002 to 1006; *reaction*, alkaline; *appearance*, generally turbid; *consistence*, glairy, viscid, frothy. On standing for some hours in a cylindrical glass vessel, an opaque, whitish deposit collects at the bottom, while the supernatant fluid becomes clear and of a faint, bluish tinge.

The *average daily amount* excreted has been placed at 1500 grams (about three pints); according to Ralfe this is probably too high, and 800 to 900 grams (less than a quart) is nearer the mark.

The specific gravity, according to some authors, may range normally as high as 1009. Saliva from different individuals may show a constant difference in alkalinity, but it varies only within narrow limits, and, while showing within certain limits in the same individual, a constant degree of alkalinity, there is a decided and constant difference in different individuals, but no constant corresponding difference in diastatic action according to Chittenden. (Charles). The *solids*, present in saliva, form only about half of one per cent. of it; half nearly of these solids are salts, the rest proteids, namely ptyalin, globulin, and serum albumin.

The alkalinity would appear to depend on the presence of alkaline bicarbonates and phosphates with, possibly, help from a combination of the ptyalin with soda. The *sediment* consists of epithelial cells and salivary corpuscles—the latter re-

sembling the colorless blood corpuscles and probably derived therefrom; under the microscope, they present the same appearance as lymph cells, which have become swollen in water and within their bodies, as long as they are uninjured, a lively movement of small molecules may be perceived.

524. **Chemical composition of saliva:** the most important constituents of saliva are the diastatic ferment or *ptyalin*, as it is called, *mucin*, and the chlorides of sodium and potassium; in addition are found traces of albumin, fat, *potassium sulpho-cyanide*, sulphates and phosphates of the alkalies and alkaline earths, chiefly calcium phosphate, also calcium carbonate, and oxide of iron. Sometimes, even in normal saliva, urea, and ammonium nitrite are found. Saliva contains small quantities of nitrogen, and oxygen, and abundance of carbonic acid. The following are analyses of the mixed saliva:

## FRERICHS.

Water.....	994.10
Solids.....	5.90
Epithelium and mucus.....	2.13
Fat.....	0.07
Mucin and traces of alcoholic extract.....	1.41
Potassium sulpho-cyanide.....	0.10
Chlorides of sodium and potassium, phosphates of sodium, potassium, and oxide of iron.....	2.19

## JACUBOWITSCH.

Water.....	99.51
Solids.....	0.48
Soluble organic bodies, ptyalin, etc.....	0.130
Epithelium.....	0.160
Inorganic salts.....	0.182
Potassium sulpho cyanide.....	0.006
Potassium and sodium chloride.....	0.084

## SIMON.

Water.....	991.22
Solids.....	8.78
Ptyalin.....	4.37
Mucin.....	1.40
Sulpho cyanide.....	1.40
Salts.....	1.40

## BERZELIUS.

Water.....	992.9
Solid matters.....	7.1
Ptyalin.....	2.9
Mucin.....	1.4
Sulpho-cyanide.....	1.4
Salts.....	1.9

## HAMMERBACHER.

Water.....	92.42
Solids.....	0.58
Epithelium and mucin.....	0.220
Ptyalin and albumin.....	0.140
Inorganic salts.....	0.220
Potassium sulpho-cyanide.....	0.004

## IN 100 PARTS SOLIDS.

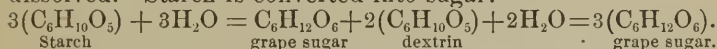
Epithelium and mucin.....	37.98
Ptyalin and albumin.....	23.97
Inorganic salts.....	38.03

## IN 100 PARTS ASH.

Potash.....	45.71
Soda.....	9.59
Lime.....	5.01
Magnesia.....	0.16
Phosphoric anhydride.....	18.85
Sulphuric.....	6.38
Chlorine.....	18.35

Enderlin gives in the 100 parts ash, 92.37 as soluble and 5.51 as insoluble, of which sodium chloride (common salt) = 61.93, sodic phosphate = 28.12, calcium phosphate and carbonate = 5.51, and sodium carbonate = 2.31.

The **functions** of the saliva are mechanical and chemical: fats are feebly emulsified and soluble substances, as sugar, dissolved. Starch is converted into sugar:



According to Mering the starch yields dextrin and maltose, and later grape sugar.

525. **Parotid saliva:** the following is Hoppe-Seyler's analysis of human parotid saliva:

Water.....	99.32
Solids.....	0.68
Mucin, epithelium and soluble organic bodies.....	0.34
Potassium sulpho-cyanide.....	0.03
Inorganic salts.....	0.34

It is a clear liquid, not viscous, but slightly alkaline. It gives no reaction for mucin, but contains albumin, ptyalin, and sulpho-cyanide of potassium.

Among more or less peculiar constituents we find paraglobulin, caproic acid, urea, and traces of sulphates. The reaction of the first secreted parotid saliva is less alkaline than that secreted later, although according to Astachewsky, it has a faintly acid reaction that gives place to an alkaline reaction,

when the mucous membrane of the mouth is slightly irritated.

On standing, the parotid secretion becomes turbid, owing to the escape of carbonic acid, and the consequent precipitation of calcium carbonate. Parotid saliva varies in quantity during the day, less being secreted immediately after a meal. (Charles).

526. **Submaxillary saliva:** in the dog, this saliva contains 99.44 water and 0.59 solids. Of the latter, mucin and epithelium form 0.066 parts, soluble organic bodies 0.17, inorganic salts 0.43. The character of submaxillary saliva depends on the exciting stimulus to its secretion; stimulation of the *chorda tympani* nerve causes a normal, rich, alkaline secretion, as noticed when acids are applied to the surface of the tongue, but in it no ptyalin is found; with long continued stimulation the organic solids diminish somewhat, though at first the mucin is specially increased; stimulation of the *sympathetic* or on application of pepper or alkalis to the tongue produces a strongly alkaline secretion, of high specific gravity, 1,007 to 1,018, but viscid, turbid, slowly flowing, rich in mucus and irregularly formed cell elements.

In *chordal saliva* (submaxillary), Heidenhain gives the solids as 3 per cent., 2.5 organic and 0.5 inorganic; but other authorities give 1.2 to 1.4 per cent. In *sympathetic saliva* (submaxillary) Heidenhain gives 5.8 per cent. solids, Eckhard 2.7 per cent. In paralysis of the nerves supplying the gland, very watery saliva is found, containing little solids or mucus. In general, it may be said of saliva that it contains a comparatively large quantity of *mucin* dissolved in an alkaline fluid, together with a sugar-forming ferment, and potassium sulphocyanide. Submaxillary saliva is comparatively poor in ptyalin, while parotid is rich in it; submaxillary saliva is rich in mucin, while parotid is poor in it. The submaxillary saliva is more alkaline than parotid and more viscid. Its average specific gravity is from 1,002 to 1,003. It contains much more carbonic acid than venous blood, but is poorer in nitrogen. (Pflueger).

527. **Sublingual saliva:** this saliva is very viscous and thready, strongly alkaline, rich in mucus and salivary corpuscles, and would appear to be the richest in solids of all salivas. Heidenhain found 2.75 per cent. of solids in the dog. Traces of cholesterin and fat have been found. (Charles).

528. **Buccal mucus:** the amount of this is inconsiderable and it contains, according to Bidder and Schmidt, 99 per cent.



of water. Its reaction is said to be acid; it contains numerous form elements, flattened epithelial cells and salivary corpuscles. Claude Bernard found buccal mucus alkaline; the acid reaction would appear to be due to alteration.

529. **Circumstances favoring the diastatic action of saliva.**—

I. Quality of saliva (parotid acting more slowly than submaxillary); quality of starch.

II. Presence of acid *up to* 0.005 per cent.

III. Dilute alkaline solutions, at 104°F.

530. **Circumstances interfering with or suspending diastatic action.**—

I. Strong alkalies, acids, temperatures above 158°F.

II. Temperature at or near freezing point.

531. **Changes in the saliva:** the *quantity* is not constant even normally. Its secretion may be excited by the sight or even thought of food, by the movements of mastication, by vapors of ether or acetic acid, or by electric excitation. If Jacobson's nerve be stimulated, a watery secretion occurs with diminished ptyalin, albumin, and salts; if there is stimulation of the sympathetic at the same time, a copious secretion is obtained, in which the organic constituents are in abundance, with a slight increase of the salts.

**Circumstances which increase the quantity in twenty-four hours.**—

I. Dry food.

II. Debility; confluent smallpox; at end of typhoid fever; ague.

III. Certain drugs: mercury, pilocarpin, eserine.

IV. Dentition.

V. Pregnancy.

VI. Hysteria; facial neuralgia; idiocy; hemiplegia from cerebral cause.

VII. Water-brash; organic diseases of the stomach, or abdominal viscera.

VIII. Stomatitis; ulceration of buccal mucous membrane.

IX. Injury from mineral acids taken internally.

Among the drugs which have been known to produce salivation are bromine, arsenic, antimony, lead, prussic acid, nuxvomica, gold, cantharides, digitalis, conium, belladonna, opium, iodide of potassium particularly, iodine, copper, croton oil, colchicum. In mercurial ptyalism, *fetor* of the breath and *sponginess* of the gums are common, but these characters have been observed in salivation from arsenic and bismuth. Extremely

minute doses of mercury will, in some people, rapidly bring on salivation.

Certain substances, as bark of pyrethrum, tobacco, etc., excite the buccal mucous membrane and lead to salivation.

532. **Circumstances decreasing the quantity of Saliva.**—

I. Fevers and inflammatory diseases.

II. Certain drugs, particularly belladonna and atropine.

533. **Circumstances rendering the saliva acid in reaction.**

I. Decomposition of organic substances in the mouth.

II. Diabetes. (Saliva acid, when secreted, sometimes contains lactic acid.)

III. Catarrh of the mouth and intestinal tract.

IV. Acute rheumatism.

V. Mercurial salivation.

VI. Occasionally in carcinoma of the liver and in typhus fever, in muguet, and frequently in dyspepsia, though in the last possibly due to acid mucus. Changes in the reaction of the saliva due to decomposition of food in the mouth must be carefully distinguished from changes due to disease. In the former case the saliva may be secreted of alkaline reaction, but in the latter case it comes acid from the ducts.

534. **Circumstances giving rise to odor in the saliva.**—

I. Gingivitis.

II. Scurvy.

III. Mercurial salivation.

IV. Angina.

A fetid odor has been noticed in these diseases.

535. **Circumstances increasing the amount of solids in the saliva or producing abnormal solid constituents.**

I. Mercurial salivation.

II. Bright's disease, (urea abundant).

III. Hysteria, (leucin found).

IV. Phlegmasia.

536. **Circumstances decreasing the amount of solids:**—

I. Chlorosis, (water increased).

537. **Tartar:** while the secretions of the mouth remain alkaline, there is a tendency to deposit lime compounds on the teeth. This constitutes *tartar*, and, although it protects the body of the tooth, it has an injurious effect on the gums. When the secretions of the mouth become acid, tartar is no longer deposited, and the decay of the teeth usually hastened. (Leffman).

Tartar is of a grayish, yellowish or brownish color; tufts of

*leptothrix buccalis* are found in it; it consists chiefly of calcium phosphate, with a little calcium carbonate, and phosphate of iron. According to Charles its average composition is as follows:

	Per cent.
Calcium phosphate.....	55 to 64
“ carbonate.....	7 to 8
Ferric phosphate.....	1 to 3
Residue: organic matter, salts of alkalis, silica, etc.....	24 to 28

Magitot held that tartar in the region of the parotid was almost wholly carbonate, other tartar phosphate; Alfred Vergne on the contrary claims that molar tartar has less phosphate than incisor, but that the carbonate is about evenly divided.

538. **Salivary calculi:** saliva exposed to the air becomes covered with a film of calcium carbonate. Concretions of this substance are often found in the salivary ducts, in which case they are known as *salivary calculi*. These are of an elongated form, dirty white color, and formed in concentric layers. They vary in size, appearance, and composition. They contain no *leptothrix*. Their average composition is according to Charles:

	Per cent.
Calcic phosphate.....	30 to 80
“ carbonate.....	11 to 15
Organic matter.....	5 to 25

Magnesium oxide, iron oxide, sodium chloride, sulphates, and potassium sulpho-cyanide, have all been found in salivary calculi.

*Uric acid* calculi have been found in the ducts in patients of an uric acid diathesis. Acids dissolve the ordinary salivary calculi very rapidly, considerable gas being given off owing to the abundance of calcium carbonate present.

## CHAPTER XVIII.

### LABORATORY WORK.

#### METALS AND THEIR REACTIONS.

539. If the substance to be examined is a metal or an alloy, certain preliminary tests will give the analyst a hint as to what line of work is to be followed.

540. 1. Observe the **color, weight, and hardness**; if the substance is very heavy, suspect *gold* or *platinum* as one of the constituents; if very light, *aluminum*; if brittle, *antimony* or *bismuth*; if yellow or bronze in color, *gold* or *copper*; if grayish, *lead*, *cadmium*, *antimony*, *tin*, *bismuth*; if very white, *silver* or *nickel*; pour on a little nitric acid, and if the substance does not dissolve, but becomes a fine insoluble powder, *antimony* or *tin* is indicated.

2. Next study the **blow-pipe and its use**.

541. The blow-pipe, as commonly used, is a small hollow cylindrical brass instrument, curved at the narrower end; it serves to conduct a continuous, fine current of air into a gas-flame, or into the flame of a candle or lamp. [Various improvements on the ordinary instrument have been devised: for example, the trumpet mouth piece, so called, is used so that the muscles of the lip may not be fatigued. Fletcher's blow-pipe is highly recommended by Essig for work in the dental laboratory: in this instrument the air-tube is coiled into a light spiral, over the point of the jet].

542. If the ordinary blow-pipe is used, the beginner must practice blowing a steady current through the blow-pipe *with the cheeks and not with the lungs*. Distend cheeks, take the blow-pipe between the lips, and practice quiet breathing for sometime. When sufficient readiness in producing the current is thus acquired, bring the blow-pipe to a flame and practice on what is called the **reducing flame** and the **oxidizing flame**. Note: a flame of gas, candle, or lamp, consists of

three parts, (a) a dark nucleus in the centre, (b) a luminous cone surrounding the nucleus, and (c) a feebly luminous mantle encircling the whole flame.

543. The **reducing flame** is produced by keeping the jet of the blow-pipe *just on the border* of a tolerably strong gas flame, and driving a moderate blast across it; the resulting mixture of the air with the gas is only imperfect, and there remains, between the inner bluish part of the flame, and the outer barely visible part, a **luminous and reducing zone**, of which the hottest point lies somewhat beyond the apex of the inner cone. This flame serves, under certain circumstances hereafter to be explained, *to take away oxygen* from a metallic compound, *i. e.* to reduce it.

544. The **oxidizing flame** is produced by lowering the gas, pushing the jet of blowpipe a little farther into the flame, and increasing the strength of the current. This serves to effect an intimate mixture of the air and gas, and an inner, pointed, bluish cone, slightly luminous towards the apex, is formed, and surrounded by a thin, pointed, light-bluish, barely visible mantle. The hottest part of the flame is at the apex of the inner cone. Difficultly fusible bodies are exposed to this part to effect their fusion; but bodies to be oxidized are held a little beyond the apex, that there may be no want of air for their combustion. For an oxidizing flame, a small spirit lamp will in most cases be sufficient.

545. **Charcoal** is used for *reducing* processes; the substances to be operated on are put into small cavities in it, scooped out with a penknife, and the reducing flame of the blowpipe is directed upon them. The fusibility of bodies is also ascertained by use of charcoal as a support. *Incrustations* are often formed on the charcoal, composed of an oxide formed after reduction, when the metallic fumes pass through the outer flame, and become *re-oxidized*. Many incrustations have characteristic colors, leading to the detection of metals.

546. **Platinum wire** and sometimes **platinum foil** are used for *oxidizing* processes, and also when fusing substances with fluxes, in order to obtain what is called a **bead**, etc., etc. The wire is cut into convenient length, say 8 centimetres (a little over 3 inches) and twisted at both ends into a small loop. When required for use, the loop is moistened with a drop of water, then dipped into the powdered flux—if any is to be used, and the portion adhering fused in the flame of a gas or spirit lamp. When the bead produced, which sticks to the

loop, is cold, it is moistened again, and a small portion of the substance to be examined is put on, and made to adhere to it, by the action of gentle heat. The loop is then exposed to whatever flame is desired.

[Many kinds of supports have been devised, but, when a small quantity of gold or silver is to be melted in the dental laboratory, the operation is usually performed on a support made of charcoal. Essig recommends that a good, solid, cylindrical piece of thoroughly charred pine coal be cut in halves vertically, by means of a saw. On the end of one half, a depression is cut for the reception of the metal to be melted, and on the flat side of the other half, extending to the end, the ingot mould is carved. The two halves are tied together with wire].

547. The simplest self-acting blowpipe is really the Bunsen gas-lamp, provided with a chimney. The flame is non-luminous, and burns without soot; Bunsen distinguishes six parts to the flame: the *base* near where the gas escapes from the burner, the *fusing zone* about one-third of the height of the flame from the bottom, and equi-distant from the outside and inside, the *lower oxidizing flame* on the outer border of the fusing zone, the *upper oxidizing flame*, which is the non-luminous tip of the flame, the *lower reducing zone* in the inner border of the fusing zone, the *upper reducing flame* in the luminous tip of the dark inner cone. Many substances give characteristic tints to a colorless flame like the Bunsen. For instance, salts of sodium impart to flame a yellow tint, potassium a violet, lithium a carmine, etc., etc.

3. Having become familiar with the use of the blowpipe, the structure of flame, etc., etc., take a portion of the substance to be examined, place it with an equal weight of sodium carbonate in a little cavity in the charcoal, and expose for some minutes to the *inner* or *reducing* flame of the blow pipe.

548. The following table from Oldberg and Long will serve to aid in the interpretation of results:

Cu.	Au.	Ag.
A red bead, somewhat difficult to fuse. No incrustation.	A yellow bead, easily malleable. No incrustation.	A white, malleable bead. No incrustation.



Pb.	Sn.	Sb.
Grayish-white globule, with yellow incrustation. Very soft.	White globules, not so readily reduced as Pb; malleable. Incrustation yellowish when hot, white when cold.	Gray, brittle globules which readily oxidize when hot. White incrustation.

#### 549. Short method for blowpipe analysis.—

I. Heat, on charcoal, equal weights of the substance to be examined and sodium carbonate. Use inner blowpipe flame. Notice *odor, metallic globule, incrustation*. [If none, go on with II]. If a result is apparent, consult the following table:

Metallic globules.	Incrustations.	Probable metal.	Remarks.
Very brittle.	White.	<b>Antimony.</b>	Metal volatilizes.
None.	White.	<b>Arsenic.</b>	Garlic fumes.
Brittle.	Yellow.	<b>Bismuth.</b>	Met'leasily fused
Red, malleable.	Little or none.	<b>Copper.</b>	Difficult to fuse.
Soft, malleable.	Yellow.	<b>Lead.</b>	Marks paper.
Malleable.	Little or none.	<b>Silver.</b>	Not oxidizable.
Malleable.	Little or none.	<b>Tin.</b>	Easily oxidized and easily fused.
None.	Yellow when hot, white when cold.	<b>Zinc.</b>	Infusible, mass greenish-white.

**Antimony** gives off white fumes, and covers charcoal with incrustation. If **arsenic** is suspected, proceed as in V. If **bismuth** is apparently the metal, confirm as follows: heat a portion of the original substance on charcoal, with a mixture of equal parts sulphur and potassium iodide: *bright red incrustation* on the cooler part indicates *bismuth*.

**Copper** may first be seen in the form of a reddish-brown substance, after heating in the the inner flame. Now heat in the point of the blue inner flame, and a metallic globule of tough copper is obtained. If the substance is **brass**, a yellow incrustation of oxide of zinc will be seen when the substance is hot, becoming white on cooling.

**Lead** may readily be recognized by its metallic globule of considerable size; the globule is soft, and may readily be flattened or cut with a knife. If the lead contain *silver*, the latter is detected by the use of bone-ash. Fill a bowl-shaped cavity in the charcoal with finely powdered bone-ash, pressed down well so as to fill the cavity with a compact mass, smooth,

and slightly hollowed on the surface. In this bone-ash, place a small piece of the lead, hold the charcoal horizontally, and direct the extreme point of the *outer* (oxidizing) flame upon the metal. The bone-ash absorbs the lead oxide formed, leaving a metallic globule of silver; the latter may be covered with a thin film of oxide, showing rainbow tints. When the colors cease, and the globule no longer diminishes in size, it is pure silver. The process is hindered by presence of tin.

**Silver** is easily reduced, but not readily fused to a globule. Sharp heat is required to accomplish the latter. When the globule is once formed it is easily distinguished from all other metals by the fact that it retains a bright metallic surface, when fused at the point of the outer (oxidizing) flame, and shows a characteristic white color.

If **tin** be suspected, take a fresh quantity of the original substance and heat with potassium cyanide instead of sodium carbonate. A very liquid slag is obtained, in which a large globule of tin may be formed without difficulty.

**Zinc** is so readily volatilized, i. e., converted into vapor, by heat that no metallic globule is formed, but merely a yellow incrustation. Moisten the latter with a dilute solution of cobalt nitrate, heat strongly, and a *green* compound (of zinc and cobalt) is formed.

II. If nothing be found by proceeding as in I, take a very little of the substance, reduce to powder, heat on borax bead, in a loop of platinum wire, in the outer (oxidizing) flame. Note the color when hot, let cool, and observe the color. Now expose to inner flame, noting color, when hot and when cold, as before. Then consult the following table:

Metals.	Outer Flame.	Inner Flame.
Chromium.	Yellowish-green.	Emerald green.
Cobalt.	Blue.	Blue.
Copper.	Blue.	Brown or colorless.
Iron.	Brownish-yellow.	Bottle green.
Manganese.	Purple or pink.	Colorless.
Nickel.	Brownish-yellow.	Muddy gray.

III. If nothing distinct has been noted in procedure as by II, moisten a clean platinum wire with HCl, take a very little of the powdered substance on it, expose to inner blow pipe flame. Observe any distinct color which may be imparted to outer flame. Consult the following table:

Metal.	Color imparted to outer flame.
Barium, Calcium, Copper, Potassium, Sodium, Strontium.	Green, Red, Bluish-green, Violet-blue, Yellow, Carmine.

IV. If no distinct color, other than yellow, be observed in III, proceed now as follows: heat a little of the powdered substance on charcoal at the point of the inner blow pipe flame, until it leaves an infusible residue. Moisten this residue with a drop or two of cobalt nitrate. Heat strongly in point of inner flame. Consult the following table:

Metal.	Appearance.
Aluminum, Zinc, Magnesium.	Blue mass, Green mass, Pink mass.

V. Finally if no color has been obtained by proceeding as in IV, mix a little of the powdered substance with dried sodium carbonate and a little charcoal, pour into a small tube closed at one end and heat. Consult the following table:

Metal.	Result.
Mercury, Arsenic, Ammonium compounds.	Minute gray globules, condensed on cooler part of the tube. Shiny black sublimate. Odor of ammonia given off. (Blox-am).

550. **Testing for metals by the wet way—apparatus, etc.:** procure a **test-tube rack**, preferably one provided with pegs on which the test tubes may be inverted so as to dry, **two dozen test-tubes** of medium size, and a **test-tube brush** or two. Wash out the test-tubes, before undertaking any tests, using the brush; take care not to shove the brush through the closed end of the test-tube. Invert over the pegs, and let drain.

In order to filter, it is necessary to have glass funnels, filter papers, a filter stand, and a receiving vessel of some kind, as for example, a beaker. Filter papers may be procured in packages already cut. It is advisable to use the Swedish paper, in size suited to the glass funnel used. Take one of the papers from the package, fold it in halves, then fold again in halves, at right angles to the first folding. A funnel shape is thus given to the paper; insert it into the glass funnel, insert the funnel into the ring of the filter-stand, place the receiving vessel beneath the spout of the funnel, then pour the solution into the paper. If it be noticed that the liquid collecting in the receiving vessel is turbid, it will be necessary to filter again, as there is probably a break in the paper.

551. In order to make **hydric sulphide** (sulphuretted hydrogen) proceed as follows: put some lumps of ferrous sulphide into a bottle with a wide mouth; bore two holes, by means of a cork borer, through a cork, and through one of the holes push a thistle tube (long tube with cup-shaped extremity) through the other hole a tube bent at right angles. Fit the cork, thus equipped, into the bottle, and slip some rubber tubing on the (right angled) delivery tube; connect the rubber tubing with a small piece of glass tubing, and cause the end of the latter to dip into distilled water, contained in a beaker. Now pour some distilled water down the thistle tube on the lumps of ferrous sulphide, until the lower end of the thistle tube is under water. Pour in a few drops of hydrochloric acid, and wait a few moments; if no bubbles of gas are seen to rise from the ferrous sulphide, pour in a few drops more of the acid. Gas will now be given off, pass out through the right angled delivery tube into the water in the beaker, revealing its presence by bubbling up through the water, and by a disagreeable odor, like that of rotten eggs. After it has bubbled ten or fifteen minutes, enough has been generated, if the bubbling has been vigorous. If not, more acid should be added by degrees.

552. In making the various tests, pour some of the solution to be tested into a test-tube—to the depth say of an inch or two—and add 15 or 20 drops of the solution (reagent) used to produce the precipitate—except in cases where the precipitate is soluble in excess (explained hereafter) when but few drops should be added. After the precipitate has formed, note its color and appearance, let it settle, pour off the supernatant liquid as much as possible, pour the precipitate remaining into

two or more test-tubes, a little in each, and add the various solutions required for testing its solubility. In making the various tests numbered 1, 2, etc., it is understood that a fresh quantity of the solution to be tested is to be used in each case, unless otherwise specified.

### 553. Reactions of the more important metals.—

**Silver:** 1. Add to solution of a silver salt, hydric sulphide or ammonium sulphide: a black precipitate of silver sulphide is produced:



2. Add hydrochloric acid, or any soluble chloride: a white, curdy precipitate of silver chloride is produced, insoluble in acids, but soluble in ammonium hydrate:



3. Add chromate or bichromate of potassium: a red precipitate of silver chromate or bichromate is formed.

**Lead:** 1. To solution of a lead salt, add hydric sulphide or ammonium sulphide: a black precipitate of lead sulphide is produced:



2. Add sulphuric acid or any soluble sulphate: a white precipitate of lead sulphate is formed:



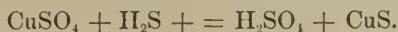
3. Add hydrochloric acid or any soluble chloride: a white precipitate of lead chloride is produced, which dissolves on the addition of much water, as lead chloride is not entirely insoluble. For the same reason, the precipitate is not formed when the solutions are dilute.

### Mercury:—

	Mercurous salts.	Mercuric salts.
1. Hydric sulphide or ammonium sulphide.	Black precipitate of mercurous sulphide. $\text{Hg}_2\text{2NO}_3 + \text{H}_2\text{S} = 2\text{HNO}_3 + \text{Hg}_2\text{S}.$	Black precipitate of mercuric sulphide. (Precipitate may be white or gray, with an insufficient quantity of the reagent.)
2. Potassium iodide.	Green precipitate of mercurous iodide. $\text{Hg}_2\text{2NO}_3 + 2\text{KI} = 2\text{KNO}_3 + \text{Hg}_2\text{I}_2.$	Red precipitate of mercuric iodide, soluble in excess.

### Copper.—

1. Add to solution of copper salt, hydric sulphide or ammonium sulphide: a black precipitate of cupric sulphide is formed:



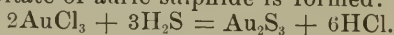
2. Add sodium or potassium hydrate: a bluish precipitate of cupric hydrate,  $\text{Cu}_2\text{HO}$ , is formed, which is converted into dark brown cupric oxide,  $\text{CuO}$ , by boiling.

3. Add ammonium hydrate: a dark blue solution is produced, containing an ammonio-copper compound.

4. Add potassium ferrocyanide: a reddish-brown precipitate of cupric ferrocyanide is formed.

**Gold:** 1. Add to a solution of gold salt, hydrochloric acid: no precipitate is formed.

2. Add hydric sulphide to solution of the terchloride: a brown precipitate of auric sulphide is formed:



3. Add stannous chloride: a purple-brown precipitate is formed.

4. Add ferrous sulphate: a brown precipitate is formed. Wash, dry, heat to redness, and metallic gold is obtained.

**Platinum:** 1. Add to a solution of a platinum salt, hydrochloric acid: no precipitate is formed.

2. Add hydric sulphide: a blackish brown precipitate is produced, which is insoluble either in nitric or hydrochloric acid.

3. Add ammonium hydrate: a yellow, crystalline precipitate is formed.

4. Add sodium hydrate cautiously, and but little of it: a brown precipitate is thrown down, soluble on addition of more of the sodium hydrate (soluble in excess).

5. Add stannous chloride: a deep brown color, but no precipitate.

#### Zinc.—

1. Add hydrochloric acid: no precipitate is formed.

2. Add hydric sulphide: no precipitate.

3. Add ammonium hydrate, ammonium chloride, and ammonium sulphide: a *white* precipitate is produced; the color may be *greenish-white*, if iron is present as an impurity.

4. Add ammonium hydrate cautiously, and in very small amount: a white precipitate is formed, soluble in excess.

5. Add potassium ferrocyanide: a white (or greenish-white) precipitate is formed.

#### Tin.—

1. To a solution of a tin salt, add hydrochloric acid: no precipitate.

2. Add hydric sulphide: a brown precipitate of stannous sulphide is formed (if the solution be a stannous one).

3. Add auric chloride to a diluted solution of stannous chloride: a purple precipitate (purple of Cassius) is formed.



**Aluminum.**—

Same reactions as for **Zinc**, 1, 2, 3. Add ammonium hydrate as in **Zinc**, 4, and a precipitate is formed, **insoluble in excess**.

**554. Short scheme for qualitative analysis of ordinary metals.**—

1. Add hydrochloric acid: a precipitate may be:

<b>Silver</b> chloride,	} White.
<b>Mercurous</b> chloride,	
<b>Lead</b> chloride,	

Add ammonia abundantly to all three precipitates; *silver* is dissolved, *mercurous* blackened, *lead* not dissolved nor blackened.

II. If nothing with HCl, add hydric sulphide: a precipitate may be:

Insoluble in ammonium sulphide.	Soluble in ammonium sulphide.
<b>Mercuric</b> sulphide. <b>Bismuth</b> sulphide. <b>Cupric</b> sulphide. <b>Cadmium</b> sulphide, yellow.	<b>Arsenous</b> sulphide, yellow. <b>Antimonous</b> sulphide, orange. <b>Stannous</b> sulphide, brown. <b>Stannic</b> sulphide, yellow. <b>Auric</b> sulphide, brown. <b>Platinic</b> sulphide, brown.

A. In order to ascertain whether the precipitate is soluble or not in ammonium sulphide, throw on a filter, wash well, wash off precipitate from filter, by means of wash bottle, into a porcelain dish, let settle, pour off supernatant liquid, then add ammonium sulphide. If insoluble in ammonium sulphide, the original solution contained either lead, mercuric, bismuth, copper, or cadmium. Cadmium is easily told by its yellow color, a mercuric salt by the change of color on addition of hydric sulphide (reddish yellow to black, with a mottled appearance). If neither of these be found, take a fresh amount of the original solution, and add ammonium hydrate: if it is copper, a beautiful blue color is seen at once. If none of the above tests are successful, it is probably bismuth, or a dilute solution of lead. To a fresh amount of the original solution, add potassium chromate: a bright yellow precipitate indicates lead. (*Dilute* solutions of lead may not be precipitated by hydrochloric acid, but yet may yield a slight precipitate of a dark color with hydric sulphide, verified by potassium chromate). If no lead be found, take a fresh amount of

the original solution, and add hydric sulphide. A black precipitate, insoluble in dilute hydrochloric acid, indicates *bismuth*.

B. If the precipitate is soluble in ammonium sulphide, the color of the precipitate produced by addition of hydric sulphide will serve to distinguish *antimony*, which yields an orange precipitate in an acid solution. Arsenic and tin (stannic) yield yellow precipitates with hydric sulphide, but the arsenic in acid solutions is distinctly *lemon yellow*. If there is any doubt, take some of the original solution, and pour it into an apparatus from which hydrogen is being evolved, and is burning at the mouth of the delivery tube. If arsenic is present, the flame will now deposit a stain on cold porcelain, soluble in sodium hypochlorite. Tin (stannous), gold, and platinum form brown precipitates, when hydric sulphide is added to solutions of their salts. To a fresh amount of the original solution, add stannous chloride: if *gold* is present, a purple color will be seen; if platinum, a brown; if tin, no change.

III. If there has been no precipitate with hydrochloric acid and none with hydric sulphide, take a fresh amount of the original solution, add ammonium hydrate, ammonium chloride, and ammonium sulphide:

**Ammonium hydrate and sulphide precipitate:**

**Iron group and earths.**

Ferrous sulphide, black.

Cobaltous sulphide, black.

Nickelous sulphide, black.

Manganous sulphide, flesh colored.

Zinc sulphide, white.

Chromic hydrate, green.

Aluminium hydrate, white.

If the precipitate produced by the ammonium sulphide is *black*, to a fresh amount of the original solution add potassium ferrocyanide: a blue precipitate indicates presence of salt of *iron*.

If the precipitate is white or greenish white, zinc or aluminium is the metal. Take a fresh amount of the original solution, and cautiously add a small quantity of ammonium hydrate, causing it to trickle down the side of the tube: if the precipitate formed is cleared, on addition of plenty of ammonium hydrate, it is *zinc*, if not, *aluminum*.

IV. If no precipitate has occurred in I, II, or III, take a fresh sample of the original solution, and add ammonium hydrate, ammonium chloride, and ammonium carbonate:

**Ammonium carbonate precipitates: Alkaline earths.**

<b>Calcium carbonate,</b>	} White.
<b>Barium carbonate,</b>	
<b>Strontium carbonate,</b>	

If ammonium carbonate produce a white precipitate, add to the original solution potassium chromate: a precipitate of yellow color indicates *barium*, rather than calcium. If there is no precipitate with potassium chromate, but a white one with ammonium oxalate, insoluble in acetic acid, but soluble in nitric, it is *calcium*, rather than barium. Calcium, barium, and strontium are readily identified by flame reactions.

In solution are left: **alkalies and magnesium:**

**Magnesium.**

**Potassium.**

**Sodium.**

**Lithium.**

**Ammonium.**

*Magnesium* salts are recognized by yielding a white precipitate with sodium phosphate, after addition of ammonium chloride, and hydrate: the precipitate is ammonio-magnesium phosphate, readily soluble in acetic acid.

*Ammonium* salts do not answer to any of the preceding tests, but, if heated with potassium hydrate, the odor of ammonia is noticeable, and fumes are seen, if a rod, moistened in hydrochloric acid, be held at the mouth of the tube.

Sodium, potassium, and lithium are recognized by flame reactions.

## CHAPTER XIX.

### LABORATORY WORK CONTINUED — VARIOUS PROCESSES: REFINING GOLD, TESTING AMALGAMS, MANIPULATION OF VULCANITE, COMPOUNDING RUBBER, ETC., ETC.

555. **Refining gold:** the separation of foreign metals from gold is a matter of great importance to the dentist, as can be inferred from Chapter VII, in which the effects of the different metals on gold are discussed. Metals may be separated from gold in two ways, by the "dry way" and the "wet way." The object of the "dry method," or *roasting*, is to convert the metals into oxides, chlorides, or sulphides. It is of importance to understand the affinities of the different metals for oxygen, chlorine, and sulphur, respectively. If, for example, the gold alloy contains a metal which has a marked affinity for oxygen, the alloy should be roasted with some oxygen-yielding substance, as potassium nitrate,  $\text{KNO}_3$  (nitre or salt-petre). If the alloy contain a metal which has but feeble affinity for oxygen, it should be roasted with a chlorine-yielding body, as mercuric chloride, or with a sulphur-yielding body, like antimony sulphide. Richardson classifies the different forms of gold, as they occur in the dental laboratory as follows:

1. Plate-scrap or clippings, and plate-filings; these need usually only be remelted, if of suitable fineness originally.
2. Mixed filings, and fragments containing solder and platinum; these should be either roasted, or reduced to gold by the "wet way."
3. Sweepings: these should be first well washed, then either mixed with class second, or separately refined.

A good method is to fuse 8 parts of sweepings with 4 of common salt, 4 of impure potassium carbonate, 1 of potassium bitartrate, and  $\frac{1}{2}$  of potassium nitrate, in a crucible.

556. **Separation of foreign metals from gold:** the most

troublesome constituents of gold alloys are tin, lead, zinc, iron, antimony, bismuth, etc., etc. Most of these are oxidizable, and roasting with nitre is usually sufficient, but tin alloys may better be roasted with mercuric chloride, and, if the alloy contain a number of the different metals, sulphide of antimony should be used.

Richardson recommends the following method:

1. Remove all traces of iron or steel by passing a magnet repeatedly through them.

2. Place the fragments and filings in a clean crucible, lined on the inside with borax, and covered either with a piece of fire-clay slab, or broken crucible.

3. Place the crucible in a furnace, on a bed composed of mixed charcoal and coke.

4. Add small bits of borax and, when the metallic mass is fluid, add the potassium nitrate (or whatever refining agent is used) in small quantities from time to time, and continue the roasting from half an hour to an hour, according to the coarseness of the alloy.

Roasting with nitre is usually sufficient, but sometimes effects partial separation only. In such a case proceed as follows:

1. Remove crucible from the fire, after roasting with nitre and let cool gradually.

2. Break the crucible, remove button of gold, separate from slag by use of hammer, put into a new crucible, and melt again.

3. Add any particular agent capable of uniting with any particular base metal known to be present; or, try, first, one refining agent then another, until sufficient separation is effected.

4. Pour the melted metals into previously warmed and oiled ingot moulds.

5. Hammer, anneal and roll the ingot, and, if still brittle, melt again with mercuric chloride.

Another method, of advantage in a greatly impoverished alloy, is the following:

1. Melt the alloy in a large crucible, adding small quantities of native antimony sulphide, until three or four times the weight of the alloy has been reached.

2. A lead-colored alloy of gold and antimony is formed; place it in a clean crucible, melt, and blow a current of air, by means of a bellows, over its surface.

3. Blow gently at first; a current strong enough to produce

visible fumes is all that is necessary. When the fumes cease, increase the heat, and before pouring out the gold throw a forcible current of air on the surface.

In case the alloy be found now malleable, but stiff or elastic, and of dull color, *platinum* is probably present and must be removed by the "wet method," which, in general, must be used when it is desired to reduce the alloy to *pure* gold, as is the case when the gold to be refined consists of very coarse filings, fragments of plates containing large quantities of solder, linings with platinum pins attached, particles of base metals, etc., etc. Proceed as follows by the method of Watt:\*

1. Dissolve the alloy in aqua regia, using 4 parts of hydrochloric to 1 of nitric, C. P. acids being used. The chloride of silver is found as a grayish-white powder at the bottom of the vessel. Let settle, and pour off supernatant liquid.

2. Add gradually to the liquid poured off, a clear filtered, solution of ferrous sulphate in distilled water. Gold is precipitated as a brown powder.

3. Let settle, filter, wash off from the filter paper, digest in dilute sulphuric acid, filter again, wash well, and the result is pure gold.

557. To determine the carat of an alloy.—

Multiply 24 by the weight of gold in the alloyed mass, and divide product by weight of the mass. Take, for example, a solder composed of 6 parts gold, and 3 of other ingredients: the weight of the gold is represented by 6, the total weight 9  $\therefore 24 \times 6 \div 9 = 16$ . The alloy is, then, 16 carats fine. When now the gold is not pure, attention should be paid to the number of carats, and deduction made accordingly. Suppose a solder contain 48 parts of 22 carat gold, and 28 parts of other constituents; here the true weight of the gold is not 48, but 44. (22 carat gold is one-twelfth alloy; one-twelfth of 48 is 4 and  $48 - 4 = 44$ ).

558. To reduce gold to a required carat: multiply 24 by the weight of pure gold used, and divide the product by the required carat. The quotient is the weight of the mass when reduced, from which subtract the weight of the gold used, and the remainder is the weight of the alloy to be added. For example reduce 10 ounces of pure gold is 18 carats:  $24 \times 10 \div 18 - 10 = 3.3 +$  ounces of alloy to be added. If the gold is not pure, allowance must of course be made by subtracting, as in the previous rule.

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\*Quoted by Richardson.



559. To raise gold from lower to higher carat: multiply the weight of the alloyed gold used, by the number representing the proportion of alloy in the given carat, and divide the product by that number representing the proportion of alloy in the required carat; the quotient is the weight of the mass, when reduced to the required carat by adding fine gold.

For example, suppose it is required to raise 16 carat gold to 18 carats: in 16 carat gold there is  $24 - 16$ , or 8, alloy; in 18 carat gold there is  $24 - 18$ , or 6, alloy. The example therefore becomes  $1 \times 8 \div 6 = 1\frac{1}{3}$ ; that is, add  $\frac{1}{3}$  of a pennyweight of pure gold to the 1 pennyweight of 16 carat gold, in order to obtain 18 carat gold.

If, now, instead of adding pure gold it be desired to add gold of some particular carat, it is merely necessary to subtract the numbers, as 16 and 18 above, from the carat instead of from 24. The example above would then become, if 22 carat gold were to be added,  $1 \times 6 \div 4 = 1\frac{1}{2}$ , that is to each pennyweight of 16 carat gold, add  $\frac{1}{2}$  pennyweight 22 carat gold.

#### 560. Methods of preparing dental amalgam alloys.—

Take a Hessian, or sand, crucible, fuse in it enough borax to fill the crucible at least one-third full, melt the tin in it over the usual dental or smelting forge-fire and, after it is melted, add the granulated silver, which, preferably, should have been heated to a low redness. The silver soon fuses in the molten tin and, after thoroughly stirring with an iron rod or clay-pipe-stem of small size, the copper, in form of small pieces of wire, should be added. After it has melted, and the mixture has been stirred, the gold is added, melted, and all is thoroughly stirred. After fusion and mixing is complete, quickly pour the fused mass into a broad, open, flat, shallow receptacle of iron or soap stone, and let cool. (Flagg.)

According to Flagg, *very slow cooling* is to be avoided, as it gives rise to almost complete separation of the silver from the tin, or, in other words, the cohesion of like molecules overcomes the adhesion of unlike ones. The end sought for is to fix the molecules, as much as possible, in the position into which they are driven by the heat. Prompt cooling secures the greatest uniformity of distribution to the components. (Flagg.)

Essig prefers to melt the platinum and silver together first, in case platinum is used, so that oxidation of the tin may not take place at the instant of union with the platinum. After

the platinum and silver have been melted, the tin and gold are to be added. Borax is to be fused in the crucible first, and, lastly, a layer of broken charcoal should be placed over the mass before the heating.

561. **Amalgamation of the dental alloys:** after the alloy has cooled, it is, by mechanical means, "cut" into "grains" or "filings," and then is ready for amalgamation with mercury. Flagg directs that this be done by **weight**: for first grade alloys—tin and silver—about 37 to 39 per cent. of mercury is needed; for second grade—*tin*, silver, and gold—about 41 to 43 per cent.; for third grade—*silver*, tin, and copper—about 46 to 48 per cent.; for fourth grade—*silver*, tin, copper, and gold, or *tin*, silver, gold, and zinc—about 48 to 50 per cent. of mercury. Place the ingredients, filings and mercury, in a ground glass mortar, and gradually incorporate the filings with the mercury, keeping the latter in the centre of the bottom of the mortar, and by a circular motion, occasionally reversed, draw in the filings little by little, and rub well with a glass pestle, having its glaze rubbed off with emery at the large end. The amalgam is then to be taken from the mortar, any adhering to the pestle scraped off, and the whole "kneaded," between thumb and forefinger. The process requires practice.

562. **Alloys and amalgams: tests:** the tests by which good amalgam alloys are recognized are partly chemical, partly mechanical. The latter will not be considered in this work. The chemical tests include the quality of the mercury, of the alloys, the "setting" test and the "color" test. Pure mercury, practically free from metallic admixtures, should be used; according to Flagg that sold in "ten pound stone bottles" is perfectly adapted for making dental amalgam.

The "setting" is tested by weighing out equal parts of mercury and alloy, which are mixed, and the buttons examined as to physical characteristics: buttons of tin and silver, *largely tin*, are very soft, having the peculiar plasticity of tin amalgams; they set slowly and retain for a long time softness, so that they may be marked by rubbing gently with the finger, and easily crushed or broken after several hours of hardening. Buttons of tin and silver, *largely silver*, are much firmer, have the peculiar crepitation of silver in making; set not so slowly, lose in an hour that exterior softness which permits of "finger-marking." Buttons of tin, silver, copper—*largely tin*—have the peculiar "feel" due to copper; the setting is

grainy, not firm, and accompanied by a characteristic *whitening* of the mass; they remain rather soft for nearly an hour. Alloys of tin, silver, and gold—largely tin—are plastic, harden reasonably well, and with reasonable firmness; alloys of tin, silver, gold—largely silver—mix with combined rigidity and plasticity, their crepitation is “short, sharp and decisive,” according to Flagg, the setting prompt, firm, and dense, and, at that length of time when buttons of *tin* and silver amalgam can be scraped by the finger-nail, those of *silver*, tin and *gold* can be readily and handsomely burnished. Alloys containing *cadmium* are recognized in amalgamating by a “slippery stick or greasy catch,” by the dirtiness in working, by the rapid, but feeble setting. *Antimony* somewhat resembles *cadmium*. *Zinc* causes adhesion of the mass to the pestle in working. The *color test* is made by the use of sulphuretted hydrogen water: gradual discoloration of alloys can be noted by exposing them to the action of a *weak solution* of sulphuretted hydrogen gas in water. [A strong solution of the gas will show the discoloration more rapidly. Where the preservation of the tooth is the main point, Flagg recommends an alloy which is discolored by the sulphuretted hydrogen water, namely one containing silver, tin, and copper; where the cavity can be well “lined,” he prefers an alloy which is not readily discolored, namely one containing gold, platinum, or zinc].

563. In testing an alloy for constituent metals, first make a preliminary examination as follows: into a test tube, drop some of the metal or alloy in form of clippings, or coarse powder, pour in some nitric acid; convenient proportions are a few grains of the metal to a drachm or two of the acid; warm over an alcohol lamp flame, being careful not to let the acid boil over out of the test-tube, as it is very corrosive and will burn hands, clothing, etc. Of the commoner metals, copper, silver, and zinc will dissolve. If the copper is in any noticeable quantity, the solution may acquire a green or blue color. Tin, gold, antimony, and platinum are not dissolved, though traces of the last two may go into solution.

564. Short method of qualitative analysis of amalgam alloys: according to Eckfeldt and Dubois,\* an idea may be had of the presence of gold and platinum from the action of the tin, which is not dissolved; but, after the action of the acid is over, shows itself as a whitish precipitate, colored from light to deep purple, if *gold* be present, or dirty-blackish color, if *platinum* be present

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\*Quoted by Flagg.

with or without gold. After some idea is thus gained, take more of the metal or alloy, say 20 grains, and dissolve in half an ounce of acid, using a *beaker*. It is advisable to use what is sold as C. P. nitric acid, strong. The beaker should not be brought into contact with the naked flame in warming; it may be passed to and fro through the flame, or warmed by dipping into boiling water. After the action is over, evaporate to dryness, in a porcelain dish, over the *water bath*, a copper vessel filled with water under which is the alcohol flame. The whole should be under a "hood" for carrying off the vapors, or in a well-ventilated room. The fumes of the nitric acid are very irritating, and should not be breathed. (I.) After the nitric acid mixture has been evaporated, which will take some little time over the water-bath, add distilled water, stir well, and filter. [Previous work has revealed the presence or absence of gold, platinum, and tin; there remain silver, copper, cadmium and zinc to be looked for].

(II.) After filtering, add some dilute hydrochloric acid—a few drops of acid in half a test tube full of water will be enough—and if *silver* is plenty a white, *curdy* precipitate will be formed.

(III.) Filter again, and to a little of the filtrate (liquid which goes through the paper) apart from the rest, add a few drops of ammonia water (made by mixing one volume of *stronger* ammonia water with three volumes of distilled water); a blue color indicates *copper*.

(IV.) To the rest of the filtrate add sulphuretted hydrogen. After the sulphuretted hydrogen water has been added a black precipitate of *copper sulphide* will result, unless modified in color by a large percentage of *cadmium*.

(V.) Filter, saving the filtrate, wash the precipitate off the filter paper into a porcelain dish, using the *wash bottle* (a flask with a perforated cork having two bent glass tubes passing down into the flask; blowing into one tube will force water out through the other in a fine stream). Boil the precipitate in the porcelain dish with sulphuric acid diluted with water (one part of acid added very slowly and with constant stirring, to four parts of water, well mixed, allowed to stand 24 hours, and decanted).

(VI.) Filter, and add sulphuretted hydrogen water to the filtrate, and then a few drops of ammonia; a bright yellow precipitate will indicate *cadmium*. Suppose now that when testing for copper as above (III), no blue color appeared with

ammonia, then test directly for cadmium, as in (IV), which, if present, will appear as a yellowish precipitate, on addition of the sulphuretted hydrogen; (*brownish yellow* indicates that silver has not been completely removed by precipitation with HCl).

(VII.) Go back now to the filtrate saved in (V) and boil it down until nearly dry to expel sulphuretted hydrogen, then add a little pure water, and solution of sodium carbonate until neutral (shown by dipping a piece of red and a piece of blue litmus paper into the mixture which, when neutral, will not change the color of either paper). A white precipitate indicates presence of *zinc*.

The above described process will enable the beginner to test the various dental amalgam alloys for the presence of those metals usually found in them. The detection of *gold, platinum, copper, cadmium, and zinc* is of importance, for all the alloys contain silver and tin. It is desirable to procure a sulphuretted hydrogen apparatus, such as a Kip generator, and some Woulfe bottles; pass the gas generated, through a Woulfe bottle, containing a little water, so as to *wash* it, then directly into the solution to be tested.

565. **Short method of quantitative analysis of amalgam alloys.**

1. Estimate the *mercury*—of an old amalgam, for example—by weighing, heating to redness, weighing again. The loss in weight indicates the weight of mercury which was present.

2. Estimate the *tin* by weighing, heating to *bright redness* with borax, adding potassium nitrate in small quantity, cooling, collecting button and globules, weighing again. The loss in weight indicates the weight of the tin.

3. Estimate the silver by rolling out the button (obtained by procedure as in 2) into a thin ribbon, boil in a platinum or glass vessel with at least two or three times its weight of concentrated sulphuric acid. Continue boiling until the acid no longer attacks the metal, let settle, pour off supernatant liquid, **save the residue**. Precipitate silver from the poured off liquid, by dipping plates of copper into it. Collect the silver, wash well, heat, weigh.

4. Go back to residue obtained in 3, wash well, dissolve in aqua regia, drive off acid by evaporation, dissolve in a large quantity of distilled water, add oxalic acid, the **gold** is thrown down, let settle, pour off supernatant liquid and save it. Collect gold, wash, dry, heat to redness, weigh.

5. To the supernatant liquid obtained in 4, add ammonium chloride, as long as there is any precipitate. Let precipitate



settle, filter, wash, dry and weigh precipitate. Every 100 parts contains 44.28 of platinum. (Essig).

6. Estimate the percentage of each metal present by dividing the weight of the metal found by the weight of the amalgam in the beginning, before anything was done to it.

566. **Tests for cements:** tests should be made both of the liquid and of the powder. The *oxyphosphate* cements consist usually of glacial phosphoric acid and oxide of zinc. Take the reaction of the liquid with blue litmus to show that it is acid. Pour a little of the liquid into a test tube, and, holding the latter inclined, let an aqueous solution of a little egg albumin gradually trickle down the side of the tube into the acid. If a zone of whitish turbidity is noticed at the juncture of the two liquids, it is glacial phosphoric acid, rather than the common acid. To prove that it is phosphoric acid rather than any other as for example, lactic or hydrochloric, add to a little of it, solution of silver nitrate, and a *white precipitate* is produced; this does not tell it from hydrochloric, but further add *barium chloride* solution, and, if glacial phosphoric acid is the one, a white precipitate will be produced. The tests then for glacial phosphoric acid are as follows:

1. Coagulation of albumin.
2. White precipitate with silver nitrate.
3. White precipitate with barium chloride.

[All these tests should be successful; hydrochloric acid gives two of them, (1 and 2) but not 3. Sulphuric acid is distinguished by the heat evolved on mixing it with water. Nitric acid coagulates albumin, but does not answer to tests 2 and 3. Common phosphoric acid, *when pure*, does not answer to test 1, nor when diluted to test 3, but, if it contains sulphates as an impurity, will answer to test 3, and it may, if not pure, answer also to test 2. The "vegetable" acids like acetic, lactic, etc., etc., do not respond to test 1]. If the phosphoric acid is in form of crystals, dissolve in as little water as possible, or melt by *gentle* heat, and then apply the tests as above. If the crystals are dry, drop one of them into a solution of egg albumin, and, if a *cloudiness or turbidity* surrounds the crystal as it dissolves, test No. 1 is successful. At red heat the crystals should volatilize. As to the *purity* of the glacial acid: *commercial* glacial acid is a hard, glassy, mass, but the pure is softer and wax-like. [Flagg says that the hard, rock-like crystals are better for dental purposes; if this is the case it would seem that the commercial article,



which is more or less contaminated with pyrophosphoric acid, and also contains phosphates of sodium, calcium, magnesium, may be used].

The acid is deliquescent, and dissolves readily in water, and in alcohol.

To test the liquid of the *oxychloride of zinc* cements, it is necessary to show that it contains *zinc*, and is a *chloride*. Take the reaction of the liquid, which should be acid. Pour a little of the liquid into a test tube, and add *hydrochloric acid*; no precipitate should be noticed. Next add *sulphuretted hydrogen*, either in gaseous form or in solution, and no precipitate should be noticed. Take a fresh amount, to which nothing thus far has been added, and add *ammonium hydrate*, (Aqua Ammoniae will do), *ammonium chloride*, and *ammonium sulphide*, and a *white* precipitate should be noticed. N. B. The precipitate may be greenish white, if there is iron present as an impurity. Now take still another sample of the liquid, and cautiously add *ammonium hydrate*, letting it trickle down the side of the tube, and a delicate white zone of turbidity will be noticed. Shake it or add plenty of ammonia, and it will disappear. All these tests, if successfully obtained, show presence of *zinc*; confirm with blowpipe. Next to prove that it is a *chloride* of *zinc*. Take a fresh amount of the liquid, and add *silver nitrate* to it; a curdy, white, precipitate becoming violet on exposure to light, and soluble in (plenty of) *ammonium hydrate*, shows the presence of a *chloride*.

In testing the *powder* used in both oxyphosphate and oxychloride cements, attention should be paid both to its ingredients and quality: first, prove that it contains *zinc* by dissolving in nitric acid, as dilute as possible, and testing as for *zinc* in the liquid; or by means of the blowpipe.

Next as to quality: its specific gravity should be 5.6, it should turn yellow when heated in a test-tube, and become white again on cooling. Try to dissolve a little in water, and notice that it is insoluble; add to a mixture of it with water, a little nitric acid and notice that it dissolves completely. To the solution thus obtained in nitric acid, (1) add *silver nitrate*: no precipitate should appear; to a fresh amount of the nitric acid solution, (2) add *barium chloride*: no precipitate should appear. Now take a fresh amount of the powder, add water to it, and a few drops of *hydrochloric acid*: then add (3) *sulphuretted hydrogen*, and there should be no discoloration; to a

fresh amount of the hydrochloric acid solution, add (4) *potassium ferrocyanide*. A precipitate appearing should not be colored green nor blue. Test (1) is for chlorides, (2) for sulphates, (3) for lead, (4) for iron. The physical characters of the powder should be as follows: according to Flagg, *dry quick fineness*, peculiar *cracking apart* of the bulk of the powder as the bottle is slowly revolved, feeling of *slight grit*; according to Morsman, the official U. S. P. oxide of zinc should be treated with nitric acid and heat (see Chapter VII), which causes loss of bulk, but not of weight.

567. **Manipulation of vulcanite, etc.:** much in regard to this subject belongs properly to mechanical dentistry. When the rubber is ready for hardening or vulcanizing the latter may be accomplished by submitting it for a time to the action of hot air, steam, or hot water. A strong boiler, called a **Vulcanizer** is usually used, the metal of which should preferably be wrought. High steam is often used in vulcanizing; it should be remembered that in raising steam, the ratio of increase of pressure or elastic force is far greater than that of the increase of temperature, and that copper, of which the boiler is composed becomes weakened at high temperatures. Wildman advises the novice to use a test-piece of rubber when first using a new vulcanizer or after setting a new thermometer. Before attempting to vulcanize a set of teeth, expose the trial piece to a temperature of 320° F., for an hour and a quarter and note the effect. In vulcanizing brown (black) rubber great care should be used in raising the heat. In the case of light-pink rubbers, the heat may be more quickly raised with safety, as they contain a relatively high percentage of foreign matters. In general raise the heat gradually to 320° F., keep it there for the time required by the particular kind of rubber, then cut off the flame and allow the vulcanizer to cool down to 212° F.

568. **To improve the color of rubber** Wildman advises exposing to action of alcohol in sunlight from six to twelve hours. **Bending hard rubber** may be accomplished after heating to the proper temperature—240° to 280° F. Small pieces, *uniformly thick*, may be softened by oiling and holding over the flame of a spirit lamp. Large pieces or those of irregular thickness may be softened by immersing in oil in a vessel and raising to the required temperature.

569. **Parting the plaster:** an ounce of castile soap (cut into thin shavings) dissolved in a pint of water, by boiling, is used for parting the plaster.

570. **Coloring plaster:** to color plaster add a little vermilion to the dry plaster.

571. **Hardening the plaster:** the operation may be hastened by mixing thick, adding common salt, or using hot water, and by combining the three methods.

572. **Compounding rubber:** caoutchouc may be mixed with sulphur and the coloring matter, either by passing repeatedly between steam-heated rollers, or by reducing the caoutchouc in the first place to pulpy or gelatinous state (by the action of some such substance as carbon disulphide) and then mixing the sulphur and coloring matter with it. [Wildman prefers to soften caoutchouc in oil of turpentine or in equal parts of coal naphtha, or benzine, and oil of turpentine]. From 5 to 50 per cent. of alcohol should be added to the solvent, in order that the latter may be at least partially recovered after the caoutchouc has softened. Wildman levigates the coloring matter and sulphur in spirit of turpentine, first grinding the coloring matter to a fine powder, then adding the sulphur and grinding thoroughly. He next adds a little of the pulpy caoutchouc, mixes thoroughly, and so on.

573. **Substances used to color rubbers:** the natural color of hard rubber composed of caoutchouc and sulphur only is a dark brown. Red oxide of iron and also vermilion are used to make red rubbers; cadmium sulphide to make a yellow, and with oxide of zinc to make a lighter yellow. Ivory black is used to produce a black rubber. Various modifications of the different colors may be made by combining the coloring materials in different proportions.

574. **Testing rubbers chemically:** to ascertain whether metallic mercury is set free in the body of the rubber by the decomposition of the sulphide (vermilion) during vulcanization, a simple method is to digest the rubber in nitric acid, then test the solution for mercury in the usual way. Metallic mercury may be seen by the microscope in many brands of red rubbers. (Wildman). **Sulphuretted hydrogen** may be proved to be given off during vulcanization by heating a sample of the rubber to  $320^{\circ}$  F., for one hour and a quarter in a suitable receptacle, and collecting the gas in a solution of a lead salt. A black precipitate indicates formation of sulphuretted hydrogen.

## CHAPTER XX.

### SALIVARY ANALYSIS.

575. A complete course in salivary analysis is as essential to the dental student as one in urinary analysis is to the medical student. First become familiar with the **physical characteristics** of the saliva: I. cause the patient to wash his mouth out thoroughly with a warm dilute solution of sodium bicarbonate, and afterwards with cold spring water, if it can be obtained, or with cold distilled water. Brush the inside of the mouth lightly with a glass rod, moistened with a little dilute acid, when the mouth will be filled with a considerable amount of clear, viscid fluid. Cause the patient to expectorate into a cylindrical glass vessel tapering at the bottom, and provided with a lip so that the sediment may be collected and examined with the microscope.

II. While it is settling, note the **color, odor, reaction, transparency, consistence, appearance of sediment, specific gravity**: color should be absent, so also odor; take the reaction with litmus paper, dipping both red and blue slips into the fluid at once; if neither change color, the reaction is *neutral*; if the blue is turned red, the reaction is *acid*; if the red is turned blue, the reaction is *alkaline*. A variety of litmus paper may now be obtained,\* which turns red in an acid liquid, and blue in an alkaline one. The transparency should not be great, for normal saliva is turbid; the consistence should be glairy, viscid, and there should be froth. Notice whether the sediment after standing some hours is opaque and whitish or whether *stringy masses* are present in it. [The latter is not likely to be the case in saliva obtained as directed in (I) but is sometimes noticed in cases of chronic gastric catarrh].

N. B. In order to note the physical characters in detail, to

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\*Parke, Davis & Co., Detroit, have supplied me with this paper.

collect and examine the sediment, and to ascertain the specific gravity, several specimens of saliva collected in separate beakers or cylinders should conveniently be procured in order to save time. The first specimen may be set aside in order that the sediment may settle in it; the second specimen may be used for observation of the color, odor and reaction, and also for the chemical tests; the third, in case of a scanty supply, may be set aside for dilution in order to ascertain the specific gravity by methods hereafter to be explained.

III. Next ascertain the specific gravity, which can be done by means of the urinometer or by use of specific gravity beads.

The urinometer consists of a glass float weighted below with a bulb of mercury, and having a stem graduated from 0 to 60 at intervals of one or two degrees; the instrument should sink to zero when floated in distilled water; a beaker usually accompanies it. If there is plenty of saliva the specific gravity can be obtained at once by floating the urinometer in the saliva, and reading off the number on the scale at the level of the liquid. It should average from 1002 to 1006, or, possibly, 1008 or 9. If the amount of saliva is scanty, the specific gravity may be obtained by dilution: take *one* part of saliva by volume (bulk), and add one part of distilled water to it so as to make enough liquid to fill the cylinder, or beaker used, say two-thirds full; take the specific gravity as before and multiply the last figure of it by 2 and the result is the true specific gravity of the saliva.

IV. Next proceed with **chemical tests**, first for the **normal** constituents, next for possible **abnormal** ones.

576. **A. Qualitative tests for normal constituents.**—

1. Boil a little of the saliva in a slender long test tube, held between thumb and forefinger by the closed end; heat the *upper part* only of the fluid. A turbidity noticed indicates presence of *albumin*.

2. To a fresh supply of the saliva add a drop or two of *ferric chloride*: a blood-red color indicates presence of sulphocyanide. This test is sometimes performed by means of prepared test-paper: immerse strips of paper in an amber-colored solution of ferric chloride, to which a few drops of hydrochloric acid have been added. Let dry. A drop of saliva will give a red spot on such paper. The red color is removed by addition of a drop of mercuric chloride.

[The test may fail altogether, in which case the saliva must be distilled with phosphoric acid, and the first of the distillate tested].

3. Collect a plentiful supply of the saliva by chewing rubber, or by inhaling, into the mouth, ether vapor: add four times its volume of water, stir well, let settle, pour off the supernatant liquid from the sediment. Prepare some starch mucilage by rubbing a little starch into a thin paste, with a little cold water, then pouring into about half a pint of boiling water. Boil for five or ten minutes and, when cool, decant the clear liquid. Pour some of the starch mucilage into a small beaker, add a little of the diluted saliva, lay aside for ten minutes in a drying oven where the temperature is about  $95^{\circ}$  to  $104^{\circ}$ ; in default of a hot chamber place the beaker some time in water of temperature of  $104^{\circ}$ , or warm the mixture very gently in a test-tube over a flame, taking care by cooling with the hand that the temperature does not rise much above  $95^{\circ}$ . Apply the tests for starch and for sugar and it will be found that the starch has disappeared wholly or in part, and that sugar has been formed, showing presence of *diastatic ferment* (ptyalin) in saliva.

[The test for sugar should be made as follows: procure what is known as Fehling's test-liquid, essentially an alkaline solution of copper sulphate, boil a little of it in a test-tube, and if it does not lose its blue color it is fit for use. Now add a drop or two of the starch mucilage on which the saliva has acted, and raise just to boiling point again; *reddish-yellow precipitate* indicates presence of grape-sugar. Compare now the action of a weak solution of *iodine* in alcohol on the original starch mucilage, and on that which has been acted on by the saliva; with the original it should form a deep indigo-blue compound].

4. Fill a tall beaker with dilute acetic acid—say one part of the ordinary acid to two or three of water—and let the saliva drop slowly into it; *stringy flakes* indicates presence of *mucin*.

5. To show the inorganic acids, evaporate the saliva to dryness in a porcelain crucible; do not withdraw the heat till the residue is well blackened or darkened from charring of the organic matter; when it is so, remove, let cool, and add a little distilled water, stirring well, and adding a drop of acetic acid. Filter and divide the filtrate into three parts; to two add a few drops of nitric acid, and to one a solution of silver nitrate; a turbidity indicates presence of *chlorides*. The precipitate thus formed should be soluble in ammonia. To the other add ammonium molybdate solution, and heat; a yellowish color, becoming possibly a precipitate, indicates presence of *phosphates*. To the third add a drop or two of hydrochloric



acid and some barium chloride; a white precipitate shows presence of *sulphates*.

6. To show the presence of *lime* and *magnesia*, take a portion of the filtrate obtained in 5, and divide it into two parts; to the first add ammonium oxalate solution and a white precipitate indicates presence of *calcium* (lime); to the second part add ammonia and sodium phosphate solution and a white precipitate indicates presence of *magnesium*. The calcium precipitate should be insoluble in acetic acid but soluble in nitric; the magnesium precipitate should dissolve completely in acetic acid.

#### 577. B. Quantitative analysis.—

**Ptyalin** may be separated nearly pure by precipitating fresh saliva with dilute normal phosphoric acid, and then adding lime-water; filter off precipitate and dissolve it in distilled water from which it is to be precipitated by alcohol, collected on a filter, washed repeatedly with a mixture of alcohol and water, dried and weighed.

**Mucin**, obtained as in the qualitative method, can be collected on a filter, washed with alcohol, dried and weighed. The weight of the saliva being known, the percentage of ptyalin, or of mucin, can be readily calculated by dividing each weight by the weight of the entire saliva used.

**Fatty matters** can be estimated as follows: a definite quantity of saliva being evaporated to dryness over the water-bath, triturate the residue carefully, scraping off any that may adhere, and exhaust thoroughly with boiling ether. Evaporate in a weighed platinum capsule, and the increase in weight of the capsule represents the amount of fatty matter present. The operation should be repeated often enough to obtain a reasonably constant result.

**Potassium sulphocyanide.** Dissolve perfectly dry potassic sulphocyanide 0.05 gram in water (say 100 C.c.), and add to it ferric chloride till no more intensity of color is produced; then measure the volume of liquid. This is the test solution *a*.

Now take a definite volume of the saliva, and place it in a small graduated cylindrical glass vessel; add to it a drop or two of hydrochloric acid and ferric chloride with brisk stirring until its maximum of intensity of color is obtained; call this *b*.

Having carefully noted the intensity of the tint *b*, place three or four similar cylinders to that holding the saliva beside it on a piece of white paper in a good light; then add to one of these by means of a graduated pipette a few C.c. of the

ferric sulphocyanide solution (*a*); make it up to the same volume as the saliva (*b*) with distilled water. After stirring well note the intensity of color by looking vertically downwards through the column of liquid, and compare it with that of the saliva. If not so deep a red tint, a fresh experiment must be made in the same way, but using more of the sulphocyanide test solution. We thus proceed till an equal intensity of color is obtained in the two columns of liquid. From the amount of the test solution *a* required we can easily calculate the percentage of sulphocyanide in the saliva. (Charles).

Each C.c. of the test solution (*a*) contains .0005 gram sulphocyanide. If, therefore, 10 C.c. of the test solution are required the amount of sulphocyanide in the saliva is  $.0005 \times 10$  or .005, and so on. Divide the amount of sulphocyanide found by the weight of the saliva and the quotient is the percentage of sulphocyanide.

The chlorides may be estimated *volumetrically*, that is by use of standard solutions, directly from the saliva after the removal of the organic constituents. Fifty cubic centimetres of saliva should be boiled and filtered. To the filtrate add an equal volume of saturated baryta solution (1 volume barium nitrate, 2 volumes barium hydrate, each a saturated solution); this precipitates the organic constituents and phosphates. Filter, and to the filtrate add, drop by drop, a standard solution of mercuric nitrate, of which 1 C.c. precipitates .01 gram of sodium chloride. The number of C.c. used shows the number of  $\frac{1}{100}$ ths of a gram of sodium chloride present. The filtrate from the baryta precipitate should be acidulated with a few drops of nitric acid before the mercuric nitrate is added.

578. II. **Special tests for constituents of oral secretions:** T. Storer How has arranged a series of **litmus tests of oral fluids** together with a system of nomenclature as follows: first take with the foil-pliers a piece of blue litmus, wet it with Parotid Saliva and put the wet piece on a leaf from a foil book. In like manner treat the Sub-max. Saliva, placing the wet piece on the leaf below the other. Thus also test between the teeth, in carious cavities, pulp-cavities, roots, sulci, pus-pockets, under calculi, plates, and bridges, etc. Make the same tests in the same order with red litmus. Fill up the blank with the other statistics, and then note and record either the unchanged color of both the blue and the red by the symbol **N** neutral, or the change of the blue to red by the symbol **A** acid; or the change of the red to blue by the symbol **Al** Alkaline, as the case may be.

As abbreviations for the different reactions, How suggests the following:

**A** —Alkaline.

**A** —Acid.

**N** —Neutral.

**I** —Slightly, alkaline or acid.

**L** —Obviously, alkaline or acid.

**U** —Decidedly, alkaline or acid.

**O** —Excessively, alkaline or acid.

[Dr. Oliver of England has prepared for use in urinary analysis litmus paper charged with a definite quantity of alkali so as to distinguish several grades of acidity in reaction, such as *sub-acid*, *acid*, *hyper-acid*, etc. It would seem as if these papers under certain circumstances might be of use in salivary analysis].

**Detection of mercury in saliva:** collect all the saliva possible in 24 hours, and acidulate it with dilute hydrochloric acid (1 part acid to 9 of water). The mixture is heated for two hours on a water bath, filtered, and filtrate marked *a*, and concentrated to half its bulk over the water bath. Go back to the precipitate on the filter, place it in a beaker filled three parts full with dilute hydrochloric acid (1 part acid to 6 water), and heat the whole over a water bath, adding from time to time small quantities of potassium chlorate, and constantly stirring to dissolve the organic residue. When this is completely dissolved, filter, and add filtrate to the previous filtrate marked *a*. Concentrate the mixed filtrates to one-fourth their bulk. The solution contains any mercury that may be present as bichloride. To prove the presence of mercury, (1) place a drop of the solution on a gold or copper coin, and touch with blade of knife; a bright silvery stain will appear. (2) Place a few strips of *pure* copper-foil in a test-tube, and add a little of the solution, and boil; the mercury will be deposited on the surface of the copper-foil. Remove the strips and wash them with very dilute solution of ammonia, and dry them between blotting-paper. Then place them at the bottom of a narrow glass tube (German glass), and apply heat; the mercury will be volatilized, and deposited as a ring of minute globules at the upper end of the tube. The character of these globules can generally be recognized by the eye. If, however, they are too small, remove the strips of copper from the tube, and dissolve the ring by the addition of a drop or so of dilute nitro-muriatic acid, and gently evaporate the solution. Dissolve the residue in a little water, and

divide into two equal portions; (a) tested with a drop of dilute solution of potassium iodide, it gives a red precipitate of mercuric iodide, soluble in excess of potassium iodide solution; (b) a drop added to solution of caustic potash gives a yellow precipitate of hydrated mercuric oxide, insoluble in excess of liquor potassæ. (Ralfe).

**Microscopic examination of the sediment:** let the saliva settle in a conical vessel as directed and examine the sediment with a power of 400 to 500 diameters; note the salivary corpuscles, various kinds of epithelial cells. With higher powers bacteria, fungi, etc., may be studied.

579. **Morphology of the human sputum:** E. Cutter has made a partial list of the forms and substances found in the human sputum:

1. Mucous corpuscles.
2. Mucous cells swarming with the moving spores, probably of the leptothrix buccalis; not found in the mouths of healthy infants.
3. Mucous corpuscles distended with crystalline and other bodies.
4. Epithelia, ciliate and non-ciliate.
5. Spirillum.
6. Vibriones.
7. Micrococcus spores.
8. Bacilli.
9. Spirulina splendens.
10. Gemiasma verdans and rubra.
11. Alcoholic and lactic acid alcoholic yeast.
12. Vinegar yeast and lactic acid vinegar yeast.
13. Mycelial filaments of vinegar and lactic acid yeasts.
14. Leptothrix buccalis spores and filaments.
15. Papillæ of tongue, usually infiltrated with spores of 14.
16. Mucor malignans.
17. Hairs of plants and animals.
18. Vegetations found in croupal membranes.
19. Pus corpuscles.
20. Blood corpuscles, white and red.
21. Clots of blood.
22. Granular tubercular masses.
23. Elastic lung fibers.
24. Inelastic lung fibres.
25. Lumen of veins and arteries.
26. Carbonized tissue from lungs.
27. Partially carbonized vegetable tissues from smoke.
28. Oxalate of lime.
29. Uric acid crystals.
30. Cystine.
31. Phosphate of lime.
32. Triple phosphate.
33. Cholesterine.
34. Calculi, made up of one or more of 28, 29, 30, 31, 32, 33. These may all come under the appellation of "gravel of the lungs."
35. Other crystals whose names have not been made out.
36. Amorphous, organic, and inorganic matters, including dust and dirt inhaled from the atmosphere.
37. Portions of feathers of animals and insects.
38. Potato starch.
39. Wheat starch.
40. Elements of animal food eaten, cooked and uncooked.
41. Elements of vegetable food eaten, cooked and uncooked.
42. Cotton fibre.
43. Silk fibre.
44. Linen fibre.
45. Wool fibre.
46. Woody fibres, pitted ducts, etc.
47. Asthmatus ciliaris.

580. **Analysis of teeth and of tartar:—**

## 1. Qualitative analysis of the teeth:

1. **To show the presence of organic matter, ossein, etc.** Digest the teeth for a day or two in dilute hydrochloric acid (10 per cent). The earthy salts will be dissolved out, and what remains will be *soft and elastic*.

2. **To show the earthy salts:** place a few teeth in a clear fire and let them remain there until perfectly white. Powder and dissolve in hydrochloric acid; dilute and add plenty of ammonia; a white gelatinous precipitate occurs of *phosphates of lime and magnesia*. Filter, and to the filtrate add oxalate of ammonium: a precipitate of *oxalate of calcium* shows itself, indicating presence of lime not as phosphate; prove that there is *carbonate* by digesting powdered uncalcined teeth in dilute hydrochloric acid, when an effervescence due to carbonic anhydride takes place.

II. Quantitative analysis of teeth: the teeth should be cleaned and reduced to powder in a mortar; weigh out 5 to 10 grams of powdered teeth, dry at  $212^{\circ}$  and then at  $248^{\circ}$  until it ceases to lose weight. 1. The loss gives the **water**. 2. Take the mass thus obtained and calcine in a porcelain crucible at as low a temperature as possible; the loss in weight gives the **organic matter**, and the residue the **ash**. It is desirable to saturate the calcined residue with ammonium carbonate before weighing, and then to heat again to an elevated temperature. 3. Dissolve with the aid of a gentle heat the ash obtained in 2, in as little moderately dilute hydrochloric acid as possible; add ammonia in excess to the solution; a precipitate is thrown down, chiefly of calcium phosphate, with a little magnesium phosphate and calcium fluoride. Filter and wash the precipitate with water containing ammonia. 4. To the filtrate add ammonium oxalate to complete precipitation, boil, filter, dry the precipitated oxalate of calcium, ignite, and weigh; the result is the amount of **calcium carbonate**. 5. Go back to the precipitate obtained in 3, dissolve in strong acetic acid with the aid of heat (calcine any remaining undissolved, and estimate as pyrophosphate), and to the solution add ammonium oxalate; boil and lay aside for 12 to 24 hours; collect the precipitated calcium oxalate on a filter, wash, dry, and ignite both precipitate and filter. Care must be taken not to heat too strongly, and it is always advisable to moisten the precipitate with ammonium carbonate before drying at a moderate heat and weighing. The result is calcium carbonate. Calculate



the total amount of lime by adding the figures obtained in 4 and 5, and making the following proportion:

$$100 : 40 = \text{weight obtained} : x$$

$\text{CaCO}_3 \quad \text{Ca.}$

6. Evaporate the filtrate of 5 to small bulk, and also the washings of 5, mix with excess of ammonia, stir well, boil, lay aside for 12 hours; collect on a filter, wash with water containing ammonia, dry, ignite to redness, weigh. Calculate the magnesia by the following:

$$174 : 80 = \text{weight obtained} : x.$$

Pyrophosphate Magnesia  
of  
magnesium. (2 molecules).

7. To the washings and filtrate obtained in 6, add a mixture of magnesium sulphate, ammonium chloride, and ammonia, lay aside for 24 hours, filter, wash with water containing ammonia, dry, ignite to redness, weigh. Calculate the phosphoric acid by the following:

$$1 : 0.216 = \text{weight obtained} : x.$$

581. III. Qualitative and quantitative analysis of tartar:

A. 1. Take a gram of tartar, calcine in air, dissolve residue in nitric acid; the part remaining undissolved is **silica**. 2. Boil the nitric acid solution for two hours with great excess of pure sodium carbonate, filter and the bases, lime, magnesia, etc., remain on the filter as carbonate or oxide. 3. Wash the precipitate well, add ammonium chloride in excess, then ammonia. A precipitate shows presence of **iron**. Now precipitate the **calcium** by adding excess of ammonium carbonate. Filter. 4. To the filtrate add sodium phosphate, and a slight precipitate of **ammonio-magnesium** phosphate is obtained, which after 24 hours is complete. Calcination gives very slight residue, so that the magnesia may be reckoned as a **trace**.

B. 1. Now take a fresh supply of tartar, reduce to fine powder, weigh, treat with boiling water, which removes soluble alkaline salts and a part of the organic matter. Filter, evaporate filtrate to dryness, calcine, and the residue consists of chlorides and sulphates in the main and should be weighed.

2. Take the precipitate obtained in 1, dry, weigh, calcine in an open porcelain crucible, weigh. Loss is animal matter.

3. Take residue obtained in 2, boil in concentrated solution of ammonium chloride which converts all the calcium carbonate into calcium chloride, filter, treat filtrate with calcium oxalate, wash the precipitate, dry, calcine, weigh, and the result is the **carbonate of calcium**.



4. Take precipitate obtained in 3, wash it off from the filter paper, dissolve in nitric acid; all dissolves except a slight residue (silica), which should be washed, calcined and weighed. The result is the amount of silica.

5. Add to the nitric acid solution obtained in 4, some ammonia—enough to overcome the acidity. The **phosphates** are precipitated. Now add acetic acid in excess; part of the precipitate dissolves, part does not. Filter. Collect the precipitate on the filter, wash it off, calcine, and weigh. The result is **phosphate of iron**.

6. The filtrate contains the calcium phosphate: neutralize with ammonia, then add ammonium oxalate, filter, collect precipitate on filter, wash, calcine, weigh, and the result is calcium carbonate. Calculate the *lime* from this.

7. To the filtrate obtained in 6 add ammoniacal magnesium nitrate, and in 24 hours triple phosphate is completely precipitated; collect on filter, calcine, weigh, and calculate the **phosphoric acid** from the weight as pyrophosphate.

582. **Urinary analysis:** the dental student should be familiar with at least the elements of urine analysis.

583. **Physical characteristics of urine.**—

*Quantity in 24 hours.*—Collect for examination all the urine a patient voids in 24 hours. If that be impossible, collect the first urine of the morning. Any clean vessel holding two quarts will do for the 24 hours' urine unless the patient be diabetic when a vessel of a capacity of a gallon or more will be necessary. Normal quantity in 24 hours about *three pints*.

*Color.*—Filter a specimen of the urine (or let settle and pour off) into a clean beaker and note whether the color be (i) *pale*, (ii) *normal* (amber) or (iii) *high* (dark).

*Odor.*—At the same time notice whether the odor be (i) *normal* (faintly aromatic), (ii) *strongly urinous* as in that of fevers, or (iii) *fetid* and *ammoniacal* as in stale urine.

*Reaction.*—The urine being in a beaker or in any vessel with a wide mouth, dip into it a slip of red litmus paper and also (using the other hand) a slip of blue. Hold the papers in the urine until they are saturated; if the *blue* paper is *red-denied* the urine is said to be *acid* in reaction; if the red paper is turned blue the urine is *alkaline*; if neither is affected it is *neutral*.

*Specific gravity.*—Procure a urinometer and a cylindrical beaker especially made for it. Fill the beaker about four-fifths full of a sample of the 24 hours' urine, remove foam

with blotting paper, let the urinometer sink slowly into the urine, when it comes to rest read whatever figure on the stem of the urinometer is on a level with the liquid. In 24 hours' healthy urine the urinometer should sink to somewhere between 15 to 25; (on some urinometers these figures are 1015 and 1025). If the sp. gr. is much below 1015, as from 1012 to 1002, it is said to be *low* and the urine is not normal; if above 1025, as from 1030 to 1060, it is *high*, and the urine is not normal.

*Transparency.*—Notice whether the urine deposits a sediment on standing. If the sediment is plainly visible the urine is abnormal except perhaps in the case of females.

#### 584. Albumin.

I. *Detection.*—There are numerous ways of finding albumin in urine. The method now to be described is one which, during past years, I have seen at least three hundred pupils of mine use successfully. The desideratum is a test which, while clinically accurate, is best suited to those not over-familiar with chemical manipulations and which causes the least amount of confusion. Proceed as follows:

1. Procure a sample of the mixed urine of 24 hours.
2. Filter or let settle and pour off free from sediment.
3. Fill a test tube half full, say, of the clear urin.
4. Into it, down the inside of the tube, cause plenty of *nitric acid* to flow.
5. Notice whether a zone or ring of whitish turbidity forms at the juncture of acid and urine—if so, *suspect* albumin. Set aside the tube.

6. Fill another test tube half full of the clear urine, add a drop or two of acetic acid, and boil thoroughly. *A whitish coagulum, precipitate or turbidity shows that sero-albumin is present in the urine.*

II. *Remarks on manipulation.*—In order to proceed as in 4, it is advisable to take up the acid in a pipette and, holding the latter in one hand with the forefinger over the top, rotate between the thumb and first and second fingers, so that the acid may slip gently down the side of the tube. I am, however, in the habit of using a special apparatus for performing this test: a small glass syringe is obtained, the nozzle of which is connected with a glass jet by means of a rubber tube. I take up acid into the syringe, then, dipping the top of the glass jet into the test tube and letting it rest against the side of the tube, exert gentle pressure on the piston of the syringe, causing the

acid to trickle slowly and gently down the side of the tube. I find this apparatus of great value in detecting small quantities of albumin, as the zone formed is very distinct and clear-cut. In such cases a column of urine an inch high in the tube, to which a like amount of the acid is added, is sufficient in amount. *The acid slips more easily and gently into the urine than the latter does into the acid*, hence I prefer the acid-urine method to the urine-acid.

A *zone or thick ring of whitish turbidity* at the juncture of acid and urine indicates *probable* presence of albumin which may be verified by the method already described in I., 6. Both tests must be successful.

In preparing the heat test the urine may be boiled in the following manner: fill the test tube three quarters full of clear urine, acidulate, hold the closed end of the tube between the thumb and forefinger, and heat the *upper part only* of the column of urine. Any turbidity formed may be seen in contrast to the clear unboiled urine below, especially if the tube be held against some dark object, as the coat-sleeve.

### III. *Chances for Error.*—

1. *A zone of color is not a zone of whitish turbidity.* Normal urine will give a pinkish zone with nitric acid; abnormal urine may give various colored zones, as brown or almost black; urine containing bile may give a play of colors, *green* prominent, at the juncture.

2. Before concluding that the nitric acid shows no albumin—especially if you go on and boil the urine and find a slight turbidity—set the tube (into which the nitric acid has been poured) aside and let it stand. *After a time a slight turbidity or whitish flakes may be noticed*, especially if the tube be held against a dark back-ground.

3. Before concluding that the heat test shows no albumin let the tube stand six hours; if then a turbidity is seen, heat again, and if it persist, albumin is present.

[The testimony in favor of the *old* tests, namely, heat and nitric acid, is very great. I advise any one studying the subject to read the report of the committee appointed in Great Britain to investigate the relative merits of urinary tests, and also the paper of Dr. Penzoldt, of Germany, on the same.]

IV. *Rough method of estimation of albumin.*—Set the second test tube—namely, that one in which the acidified urine has been boiled—aside, and then note the amount of albumin which has settled. If the amount is *insignificant* the loss of

albumin in 24 hours is under 2 grams (31 grains); if *moderate*, from 6 to 8 grams (93 to 124 grains); if *considerable*, from 10 to 12 grams (155 to 186 grains); if *very large*, about 20 grams (310 grains)—(Charles). Boil daily, in the same sized test tube, the same amount of urine passed at about the same hour of day, adding 3 or 4 drops of acetic acid. Lay the tube aside and compare results with those of a preceding day.

*Clinical significance.*—Six to 8 or 4 to 10 grams of albumin in 24 hours, moderate cases of albuminuria; 10 to 12, or up to 30 grams in 24 hours, severe cases. Percentage in acute cases  $\frac{1}{10}$  to  $\frac{1}{2}$  on the average; seldom over 1 per cent., though it may rise to 4.

Two grams in 24 hours, but little influence on blood or nutrition; 6 to 8 grams, moderate; 10 to 12, considerable.

V. *Quantitative estimation.*—After sero albumin has been found by the method described under “Detection,” and if the physician be not satisfied with the rough method of estimating given in IV, let him try Tanret’s method. First make up a solution as follows:

	Grams.
Potassic iodide.....	3.32
Mercuric chloride.....	1.35
Water.....	64.00
Acetic acid.....	20 c. c.

Pour some of this solution into a graduated burette filling it to a certain mark, and add, drop by drop, to the filtered urine; proceed slowly, and after a little while let the urine settle before adding any more of the Tanret’s solution. Then add just one drop and if it produces turbidity, go on very slowly, drop by drop, until you notice that there is very little turbidity produced by each drop. Then stop, let settle again, and again try just one drop. Proceed in this manner until a drop no longer causes turbidity. Then read off on the burette the number of cubic centimetres of solution you have used. Each cubic centimetre means one-tenth of a gram (1.54 grains) of albumin.

If, therefore, you have used 10 cubic centimetres of the solution before the turbidity ceases, then the specimen of urine contains 1 gram or 15.4 grains of albumin.

Measure the amount of urine you have used (which should be a sample of the 24 hours’ urine); divide the quantity of all the urine passed in 24 hours by the quantity you have used in the estimation, and multiply the result by the amount of albumin found, and the product will be the total amount of albumin passed in 24 hours.

[One of the neatest ways of estimating albumin is that of Esbach, of Paris. The Esbach method was described by Veale in the British Medical Journal of May 10, 1884, and a brief notice of it is to be found in the *Lancet* of January 23, 1886, by Mr. Bloomfield. It is used by Dr. Debout d'Estrees, of Centrexeville, and described by Dr. F. R. Cruise, of Dublin, in his admirable paper on the "Quantitative Examination of Albumin, Sugar, etc., in Urine"].

585. **Sugar**—tests:—

A. In most cases where the specific gravity of the urine is high, the quantity voided daily large, the smell of the urine sweetish, and especially the *taste* of the urine sweetish, the urine itself sticky—when all these conditions are found, the detection of sugar with Fehling's solution is a matter of great certainty. Boil the Fehling's solution, add a few drops of the urine, boil again and a copious, reddish-yellow precipitate of cuprous oxide will indicate, chemically, that sugar is present.

B. When, however, the case is not one of confirmed diabetes mellitus, but one where the sugar, if any, is in less quantity than described in A., and when perhaps other constituents interfere—in such a case try the method of Charles: drop the urine slowly into a little boiling, diluted, Fehling's solution until rather less than an equal amount of the urine has been added. If much sugar is present the reddish-yellow precipitate is soon seen. If very little sugar is present it may take from *five to twenty minutes* before the precipitate is seen; the boiling, however, must not be kept up, but after the urine and boiling solution are well mixed it must be stopped.

Sometimes the reaction fails unless the urine is diluted before being tested. The presence of substances acting on Fehling's solution other than sugar may give rise to a strong, yellow coloration after the urine has been boiled and set aside for a few minutes. In case of doubt mix *cold*, dilute Fehling's solution and the urine, equal amounts, and set aside, without heating, for 24 hours, and a reddish-yellow precipitate will be found if sugar is present.

Lastly, to make certain of the presence of sugar, add solution of sugar of lead (plumbic acetate) to the urine, filter, and test the filtered liquid for sugar as above.

*Quantitative estimate.*—

I. Rough method: collect urine of 24 hours. Take specific gravity. Multiply last two figures of the sp. gr. by 2 and this result by the number of litres of urine passed in 24 hours.

Subtract 50 and the result is the amount of sugar in grams. Multiply by  $15\frac{1}{2}$  to get it to grains. Suppose total amount of urine in 24 hours be 4 litres; sp. gr. 1036.  $(36 \times 2 \times 4) - 50 = 238$  grams of sugar in 24 hours' urine.

II. Fehling's method: make up a solution as follows:

(a) 34.64 grams of C. P. crystallized copper sulphate dissolved in moderately warm, distilled water, and then dilute up to 500 c. c. with cold, distilled water. Preserve in a stoppered flask.

(b) Dissolve 173 grams of Rochelle salt (*in pure crystals*) in 100 c. c. of a caustic soda solution having a sp. gr. of 1.34. Dilute up to 500 c. c. Preserve in a stoppered bottle. For use mix equal volumes of the fluids (a) and (b). Shake together and there results a dark blue fluid of which 10 c. c. will show 0.05 gram sugar.

Proceed as follows: dilute the urine with ten to twenty times its volume of distilled water. Place the dilute saccharine solution in a burette. Pour 10 c. c. of Fehling's solution into a deep porcelain dish or small flask and dilute with 40 c. c. of water. Place the dish over a lamp and heat till it boils, then let the diluted saccharine urine flow into it gradually. Boil again and keep adding the urine till the blue color has disappeared, (best observed by tilting the porcelain dish from time to time after the precipitate has been allowed to subside.) [In case a few drops of the hot solution filtered through a small, thick, Swedish filter, give a brown color with acetic acid and potassium ferrocyanide, the operation is not completed. More urine must be added, drop at a time, until on removing a few c. c. from the hot solution no copper is thus found.]

Multiply 0.05 by 100 and divide by the amount of urine used in reducing the 10 C.c. of Fehling. Multiply the quotient by the figure indicating the dilution of the urine.

*Example.*—Suppose the urine to have been diluted with ten times its volume of water. Suppose 12 C.c. of it used in reducing 10 C.c. of Fehling's solution: Then  $\frac{0.05 \times 100}{12} = 0.416$ .

$0.416 \times 10 = 4.16$  per cent. of sugar in the urine.

III. Circular polarization: by far the readiest method of estimating the quantity of sugar is by polarization. Polariscopes are now specially constructed for the purpose of estimating sugar. By the Yvon-Duboscq diabetometre the estimation can be made in ten minutes. The urine must be previously precipitated with lead acetate and filtered.



586. **Bile:** urine containing bile is yellowish brown to greenish. Froths readily and the froth is of a characteristic deep yellow color.

*Test.*—Add to nitric acid a drop of strong sulphuric: let trickle down side of tube into the urine. Play of colors at juncture among which green is most prominent indicates bile.

587. **Sediments.**—

(a.) *Urates.*—Color of urate sediment usually *red*; may be *pale*. Sediment of urates is noticed during functional derangements of the digestive organs, particularly in cold weather. Heat clears the sediment.

(b.) *Earthy phosphates.*—Usually of light color and found in urine of rickets, osteomalacia and many other neuroses; in dyspepsia and overwork. In chronic affections of the bladder, triple phosphate will be found in sediment. *Test:* acetic acid dissolves a sediment composed of phosphates.

(c.) *Pus.*—Urine turbid when voided, clears somewhat on standing, depositing a dense yellowish-white sediment; later the sediment is slimy, ropy, viscid and tenacious. Pus in the urine means inflammation somewhere in the urinary tract. In women it may be due to leucorrhœa. The urine is usually acid when pus comes from the kidney, alkaline when from the bladder. Any blood present will usually lie on top of the pus in renal suppuration but be mixed with mucus and pus in vesical. *Test:* if the sediment can be drawn out in long, tough strings, pus is present. If it is not stringy, add caustic potash, (few drops) and it may become stringy if pus is present.

(d.) *Blood.*—Urine usually blood-red or brownish with black, smoky or greenish tint, and red or brown sediment on standing. Kidney blood not so red as blood from ureters, bladder or urethra. Clots often present when blood is other than kidney in origin. Presence of blood in the urine means a hæmorrhage from some part of the uropætic tract. *Permanent* presence of blood very unfavorable. *Test:* take equal parts of spirit of turpentine and tincture of guaiac. Shake well, and let an equal amount of urine and sediment trickle down the test tube into the mixture. A blue coloration, very slowly appearing at the juncture of the mixture and the urine indicates the presence of *blood*.

(e.) *Uric acid.*—*Brown specks* in the sediment or on sides of the glass are uric acid crystals. The sediment is normal after ten hours. Abnormal in three or four hours and found

in rheumatism, convalescence from fevers, chorea, some forms of diabetes, enlarged spleen, middle periods of Bright's disease.

(f.) *Calcium oxalate*.—Sediment light in color, small in amount, easily scattered. Cleared by nitric acid but not by acetic. Of significance in nervous disorders. Microscope shows small, colorless crystals, in shape that of the reverse of a letter envelope, or sometimes that of a dumb-bell. Patients in whose urine this sediment is found often complain of great urgency in voiding urine, pains in the back and loins, etc. The sediment is not easily identified by the nitric acid test unless the urine is free from albumin.

(g.) *Sediments identified by the microscope*.—Urine often contains a noticeable sediment not answering to any of the preceding tests. In this case examine with a power of 400 diameters for *tube casts*, *epithelia*, *fungi*, *spermatozoa*, etc. In cases where the urine contains albumin, the finding of *tube casts* and *renal epithelium* with the microscope will indicate the presence of renal disease. Urine containing albumin or sugar often has a sediment composed of *fungi*. A barely perceptible sediment in otherwise clear urine should be carefully examined for *spermatozoa* in cases where masturbation, etc., is suspected. Where phosphates are found by chemical tests look for prismatic crystals of *triple phosphate*.

588. **Normal constituents:** these are urea, sodium chloride, the phosphates, sulphates, urates, coloring matter, etc., etc. *Quantitative* estimation only is of clinical importance.

(a.) *Urea*.—The amount of urea excreted by a patient in a given time furnishes the physician information of the greatest importance as bearing upon diagnosis, prognosis, and treatment. It is in general an index of the manner in which the various physiological functions of the organism are performed, and, in particular, in certain kidney diseases, it enables the physician to foresee and guard against danger.

*Estimation of urea:* this may be performed approximately and with sufficient accuracy for clinical purposes by use of the method of Fowler.

Add 7 volumes of Squibb's solution of chlorinated soda to 1 volume of urine, having first taken the specific gravity of each, separately, with the urinometer. Effervescence takes place on mixing the two liquids. Shake well and stand aside for two hours. Take specific gravity of the mixture and set the figure down. Then multiply the sp. gr. of the pure hypo-

chlorite by 7, and add it to the sp. gr. of the pure urine. Divide sum by 8, and from the quotient take the sp. gr. of the mixture. Multiply the difference by .77, and the result is the percentage of urea.

*Clinical significance.*—The average amount of urea in normal urine may be considered 26 parts in the 1000 or, roughly,  $2\frac{1}{2}$  per cent. Urea is *increased* in most acute diseases; often enormously so in diabetes mellitus; it is *decreased* in the last stages of Bright's disease where estimations should be made carefully and often, steady or marked decrease being an unfavorable sign.

(b.) *Sodium chloride.*—It is important in diseases like pneumonia where there is inflammation with exudation, to estimate the chlorides. This can be done approximately as follows: procure half a dozen test-tubes, of the same size. Make a mark with a file half way up each one of them; make another mark an inch say above this one, being careful that the marks on all the tubes are the same distance from the end of the tube. Fill the tube half full of urine, then add a drop or two of nitric acid, and then solution of silver nitrate (1 in 10) pouring it in up to second mark. Shake well and let precipitate settle. Set tube aside and next day repeat the operation in a second tube and compare results, noting height of ppt. If the precipitate grows less and less in amount it is unfavorable; if more and more, favorable. It is well for each examination to have the urine of 24 hours from which to examine a specimen.

(c.) *Phosphates.*—Earthy phosphates, (calcium and magnesium) can be easily estimated approximately. Proceed precisely as in (b) only instead of adding nitric acid and silver nitrate, add *ammonium hydrate* alone and heat. A precipitate forms; let it settle and note height from day to day. The ordinary Aqua Ammoniae will do, care being taken to keep the bottle tightly corked. *Increase* of phosphates is sometimes an unfavorable sign in nervous disorders.

## APPENDIX.

**Analysis of amalgams:** various analyses of the different amalgam alloys are made and published from time to time, but there is often a question raised as to the accuracy of the figures given. At present I shall quote the following only:

ANALYSES BY PROF. E. S. WOOD, OF THE HARVARD MEDICAL AND DENTAL SCHOOLS.

Arrington's Amalgam.—Silver, 40 per cent.; tin, 60.  
Diamond Amalgam.—Silver, 31.76; tin, 66.74; gold, 1.50.  
Hood's.—Silver, 34.64; tin, 60.37; gold, 2.70; iron, 2.29.  
Johnson & Lund's.—Silver, 38.27; tin, 59.58; platinum, 1.34; gold, 0.81.  
Lawrence's.—Silver, 47.87; tin, 33.68; copper, 14.91; gold, 3.54.  
Moffit's.—Silver, 35.17; tin, 62.01; gold, 2.82.  
Townsend's.—Silver, 40.21; tin, 47.54; copper, 10.65; gold, 1.6.  
Townsend's Improved.—Silver, 39.00; tin, 55.69; gold, 5.31.  
Walker's.—Silver, 34.89; tin, 60.01; platinum, 0.96; gold, 4.14.

In subsequent editions I hope to give more information regarding the constituents of the various amalgams. I have, at present, record of a large number of analyses but I prefer to verify them before publication.

## ERRATA.

- Page 13, section 96, for 2 15 read 2<sub>5</sub>.  
14, line 28, for "millgrammmes" read "milligrammes."  
17, section 99, for "sense" read "senses."  
18, line 14, for "defninite" read "definite;" line 30 for "or" read "nor," and for "but an" read "but of an;" line 42, for "each" read "but each."  
19, rule 2, for "smybols" read "symbols."  
25, example 10, answer 6, for "potassum" read "potassium."  
27, line 13, for "envolved" read "evolved."  
29, example 15, answer 4, for  $\text{Fe}(\text{SO}_4)_3$  read  $\text{Fe}_2(\text{SO}_4)_3$ .  
30, line 21, for  $\text{ClO}$  read  $(\text{Cl O})_n$ , and for  $\text{PH}_2\text{O}_2$  read  $(\text{PH}_2\text{O}_2)_n$ ; line 37 for "16" read "15".  
31, example 17, answer, for "plumbic" read "Plumbic."

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